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**316b DEMONSTRATION REPORT FOR THE
ARKANSAS EASTMAN PLANT ON THE
WHITE RIVER**



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September 22, 2003

Mr. Kelly Meadows
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Dear Mr. Meadows:

Enclosed is a copy of the 316b Demonstration Report that was prepared by Geo-Marine, Inc. in 1981 for Eastman Chemical Company, Arkansas Operations.

If you have any questions, please call me at (870) 793-9079.

Very truly yours,

J. W. Ross

swj

Enclosure



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316b DEMONSTRATION REPORT FOR THE
ARKANSAS EASTMAN PLANT ON THE
WHITE RIVER

Prepared for
Arkansas Eastman Company

By
Geo-Marine, Inc.

11 June 1981

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I. INTRODUCTION

In accordance with requirements pursuant to the evaluation of adverse impact of cooling water intake structures on aquatic ecosystems under 316(b), Public Law 92-500, this report has been prepared for submittal to the U.S. Environmental Protection Agency (USEPA), Region VI. The report is hereby submitted as support for a decision as to whether or not the cooling water intake system for the Arkansas Eastman Plant near Batesville, Arkansas, represents best available technology for minimizing environmental impact while insuring the protection of a balanced indigenous aquatic population in the site vicinity. The study has been completed in accordance with the USEPA draft guidelines for section 316(b) evaluations.¹

A plan of study was developed by Geo-Marine, Inc., in conjunction with the USEPA Region VI, to perform both in-plant and source water sampling over a one year period. The principle objectives of this study were to provide a sufficient data base from which estimates of annual rates of entrainment and impingement could be made and to determine the temporal patterning of entrainment/impingement mortality over a single sampling year.

II. EXECUTIVE SUMMARY

The Arkansas Eastman Plant is located about 7 miles southeast of Batesville, Arkansas, on the White River. The plant's intake structure was designed in 1974 by Garver and Garver, Engineers, to accommodate 120,000 gallons per minute. Under the plan of study, to predict the effect of future intake rates, one conduit was blocked, and a 16,000 gpm per pipe rate was obtained on days of survey. This increased the intake flow by a factor of 2 and simulated an intake velocity of a factor of 4 above the present plant pumping practice. This, coupled with the low White River flow during the period of the survey, gave pumping rates which reached 2.4 percent of White River flow. This is equivalent to the percentage projected with the plant intake operating at design capacity of 120,000 gpm and the river at normal flow (USGS 41-year average, 10,040 cfs).²

The study consisted of a one year survey. Impingement rates were sampled weekly for one year; entrainment rates of phytoplankton and zooplankton were sampled monthly for one year; entrainment rates of fish eggs and larvae were sampled weekly from March through September 1980; and entrainment rates of macroinverte-

brates were sampled weekly from March through August 1980. Source water sampling of fish eggs and larvae and macroinvertebrates was performed on a monthly basis from March through September (omitting macroinvertebrate sampling in September). In addition to this sampling, source water and intake canal bathymetry and current direction and velocity were measured.

The results show low involvement and, therefore, impact on the aquatic biota of the White River. Concerning impingement, only 11 fish and one reptile were collected in 51 24-hour surveys. Entrainment rates of phytoplankton and zooplankton were low because of the low volume of water intake in comparison with river flows.

Entrainment mortality of macroinvertebrate drift and fish larvae were compared with standing crops passing by the plant as computed from source water densities at known river flow rates. It is estimated that about 0.7 percent (between 0.4 and 1.3 percent) of the macroinvertebrate and about 0.7 percent (between 0.2 and 1.8 percent) of the larval fish populations were entrained through the intake structure. The effects on the standing crops in the White River are considered minimal.

It is concluded that the design and placement of the Arkansas Eastman Plant intake system is such that low involvement with the White River biota is the case. As shown by the data collected, the continued operation of the system is not adversely impacting the local aquatic populations at intake rates of 16,000 gpm and intake velocities representing 32,000 gpm.

III. PLANT LOCATION AND DESIGN

The Arkansas Eastman Plant is located about 7 miles southeast of Batesville on the White River at river mile 286 (Figures 1 and 2). The plant uses river water to operate a steam generation system, for condensing water in air conditioning equipment, for mechanical equipment cooling, and for certain processes. At the present time, the plant intakes water at a rate of 8,000 gpm under normal operation.

The intake structure is located about 290 ft. from the river bank and has a short intake canal (Figures 3 and 4). Intake water is drawn through two 72-inch diameter intake conduits to an intake box in which there are two traveling screens, two 8,000 gpm pumps, and one 16,000 gpm pump (Figures 5 and 6). As is detailed later, one of the intake conduits was blocked for purpose of the year-long 316b study.

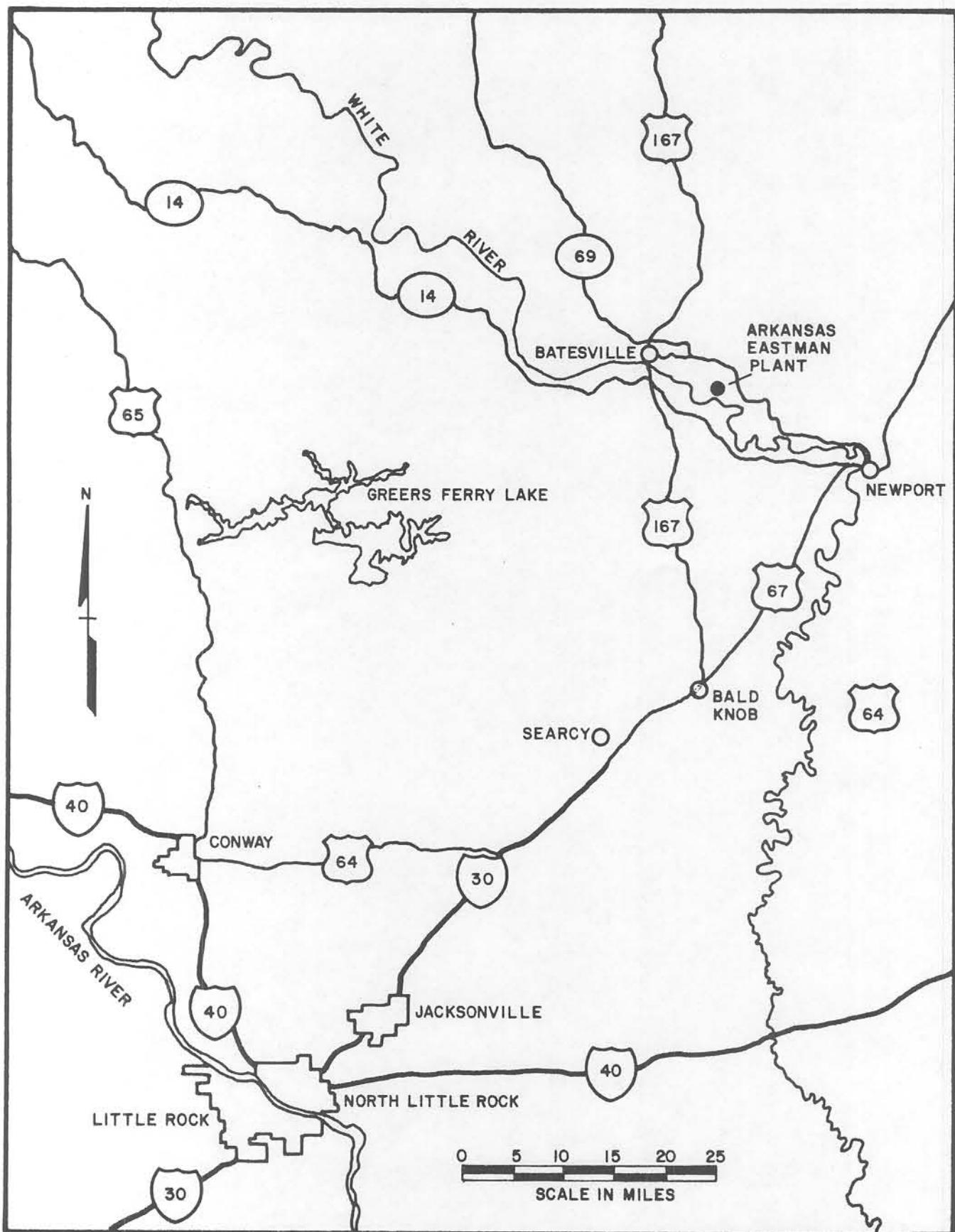


Figure 1. Location of the Arkansas Eastman Plant.

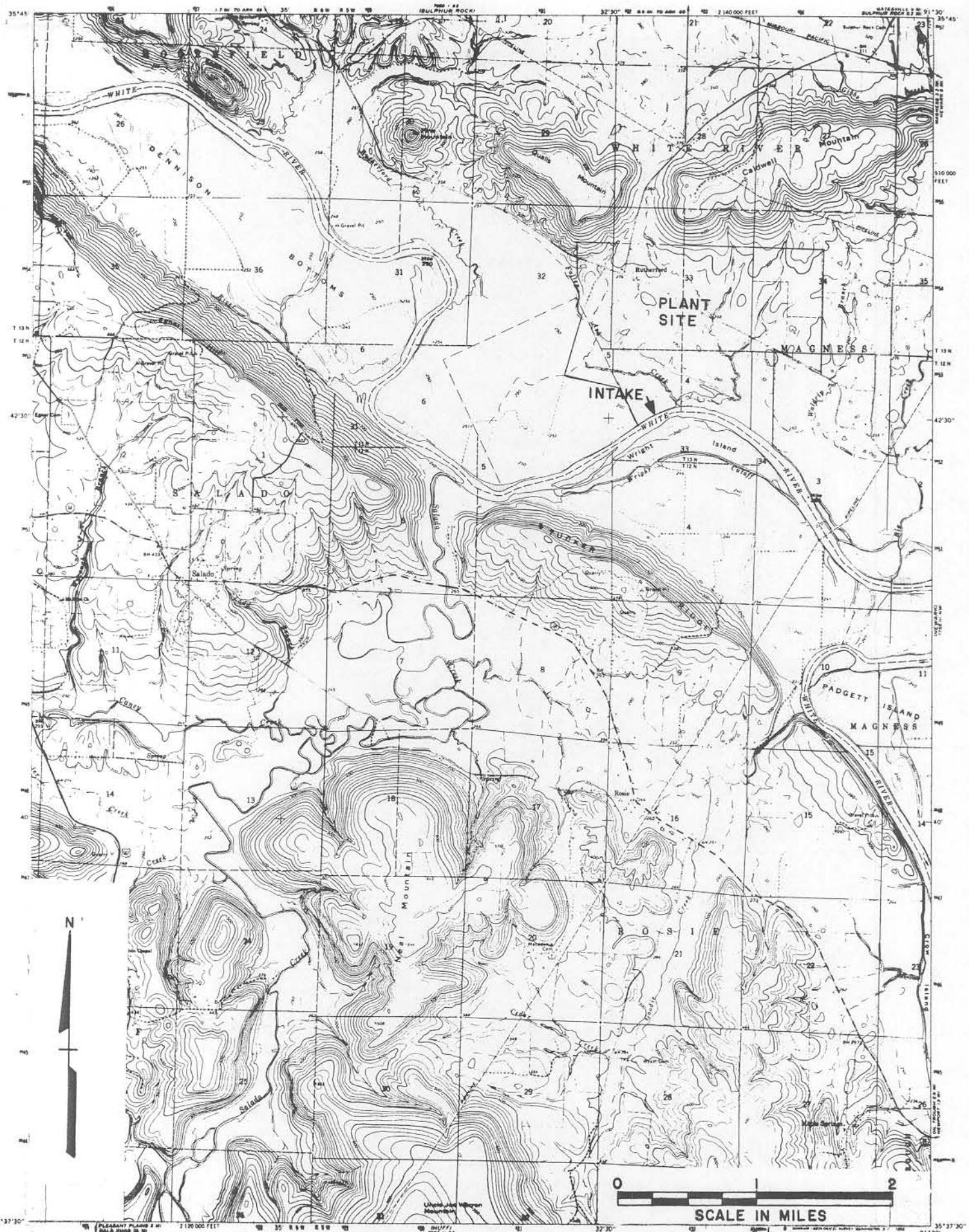


Figure 2. Arkansas Eastman Company plant location on the White River.

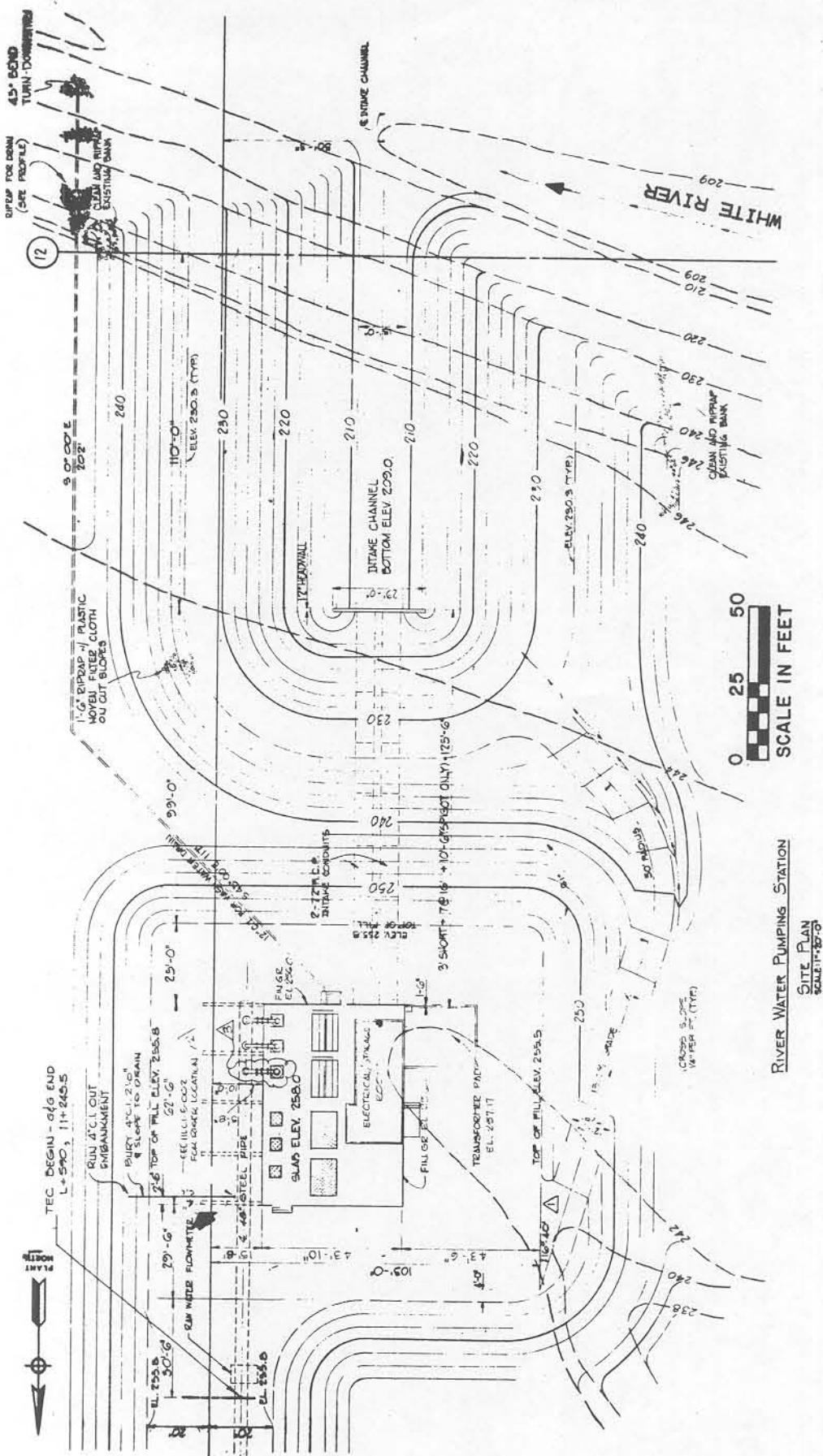


Figure 3. Overview of plant intake structure and canal.

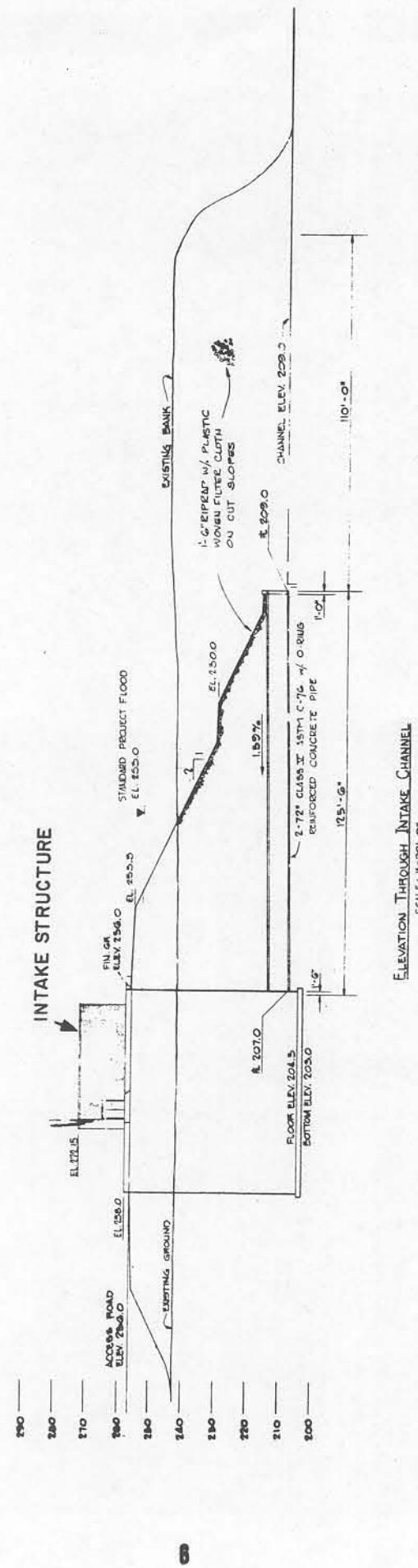


Figure 4. Side view of plant intake structure and canal.

PLANT
NORTH

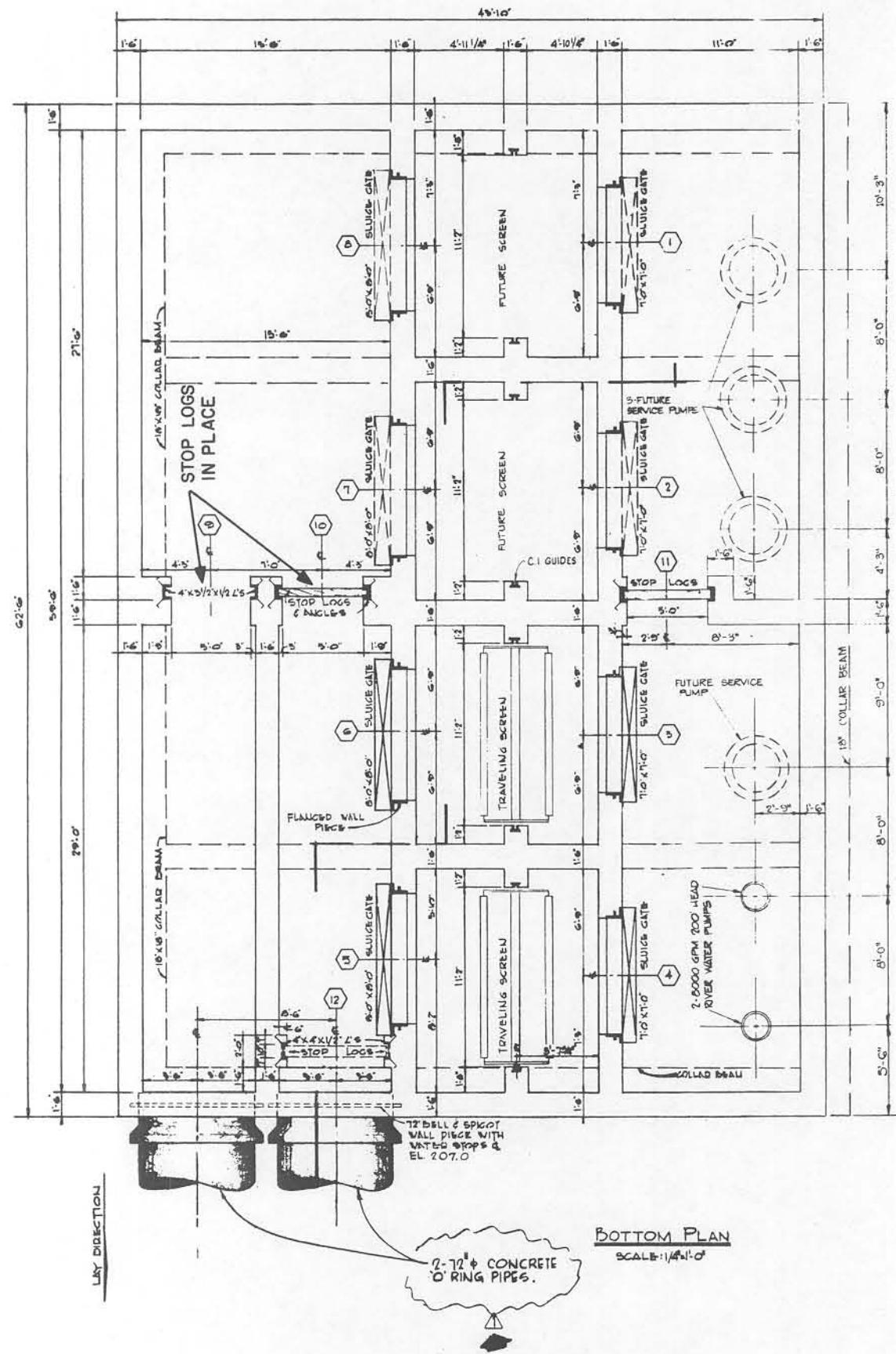


Figure 5. Top view of intake structure.

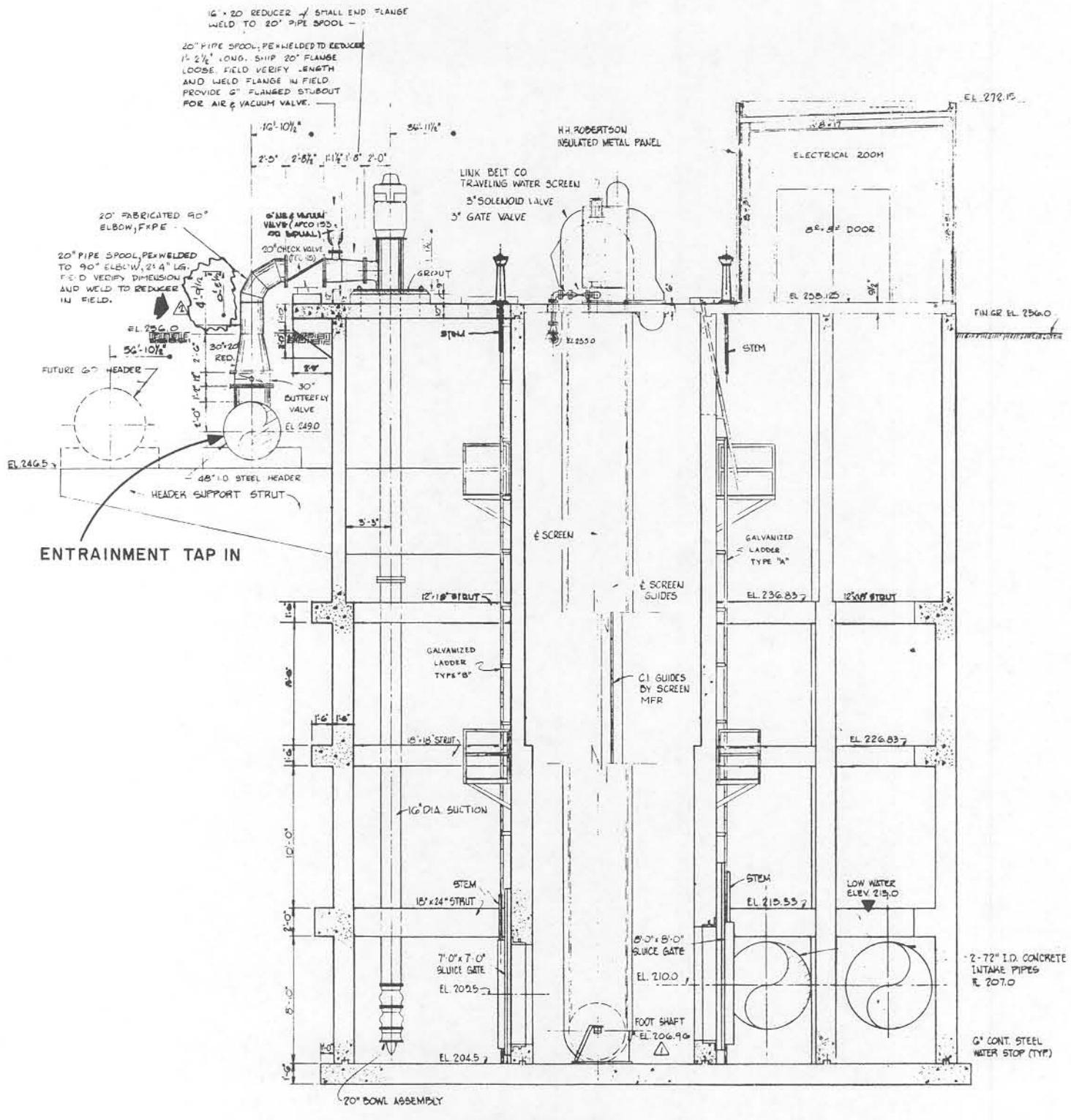


Figure 6. Side view of intake structure.

IV. ENVIRONMENTAL SETTING

Flow on the White River is regulated primarily by Norfolk Reservoir (completed in 1943) and Bull Shoals Reservoir (completed in 1951). River flow recorded at the USGS gaging station at Calico Rock (river mile 359.1) averages 10,040 cfs (41 year period of record).² Annual mean low flow recorded at Calico Rock was 3,870 cfs in 1967 while the highest annual mean flow was 17,200 cfs in 1973.² River flow measured at the plant during the survey year is presented in Figure 7. The annual mean flow of the river during the survey year was 4,323 cfs, which is 43 percent of the normal mean flow at Calico Rock.

Water temperatures measured daily at the plant throughout the survey (1 March 1980 through 16 February 1981) are shown in Figure 8. The highest temperature recorded was on 12 September 1980 (80°F) while the lowest recorded temperature occurred on 10 January 1981 (36°F).

Mean concentrations of dissolved oxygen in the river measured in the area of the site during the spring of 1974 were above 10.0 ppm indicating 100 percent saturation at a water temperature of 57°F (Acad. Nat. Sci. Phil. 1974³). The pH values recorded during the same study ranged from 7.6 to 8.0. The White River is characteristic of lower Mississippi River Basin waters exhibiting low concentrations of major cations and anions, low nutrient levels and dissolved oxygen near saturation (Acad. Nat. Sci. Phil. 1974³).

The White River from Batesville to downstream just below the site is characterized as having a diverse fish fauna, i.e., a large number of species each with relatively few individuals (Acad. Nat. Sci. Phil. 1974³). The number of species recorded in the area of the site ranged from 24 (Arkansas Game and Fish 1980⁴) to 36 (Acad. Nat. Sci. Phil. 1974³; Halterman 1979⁵). USEPA (1978⁶) collected 46 species of fish from an area of the White River 13 to 22 miles downstream from the Eastman site. The cyprinid (minnow) is the dominant family encountered, being represented by the greatest number of individuals. Common sport fish encountered in the area are largemouth bass, spotted bass, bluegill, white crappie, black crappie, white bass and channel catfish.

Benthic sampling conducted by the Academy of Natural Sciences of Philadelphia during spring, 1974, in the vicinity of the plant site revealed that algal and rooted aquatic plant growth appear to be limited by rapid fluctuations in water level, rapid

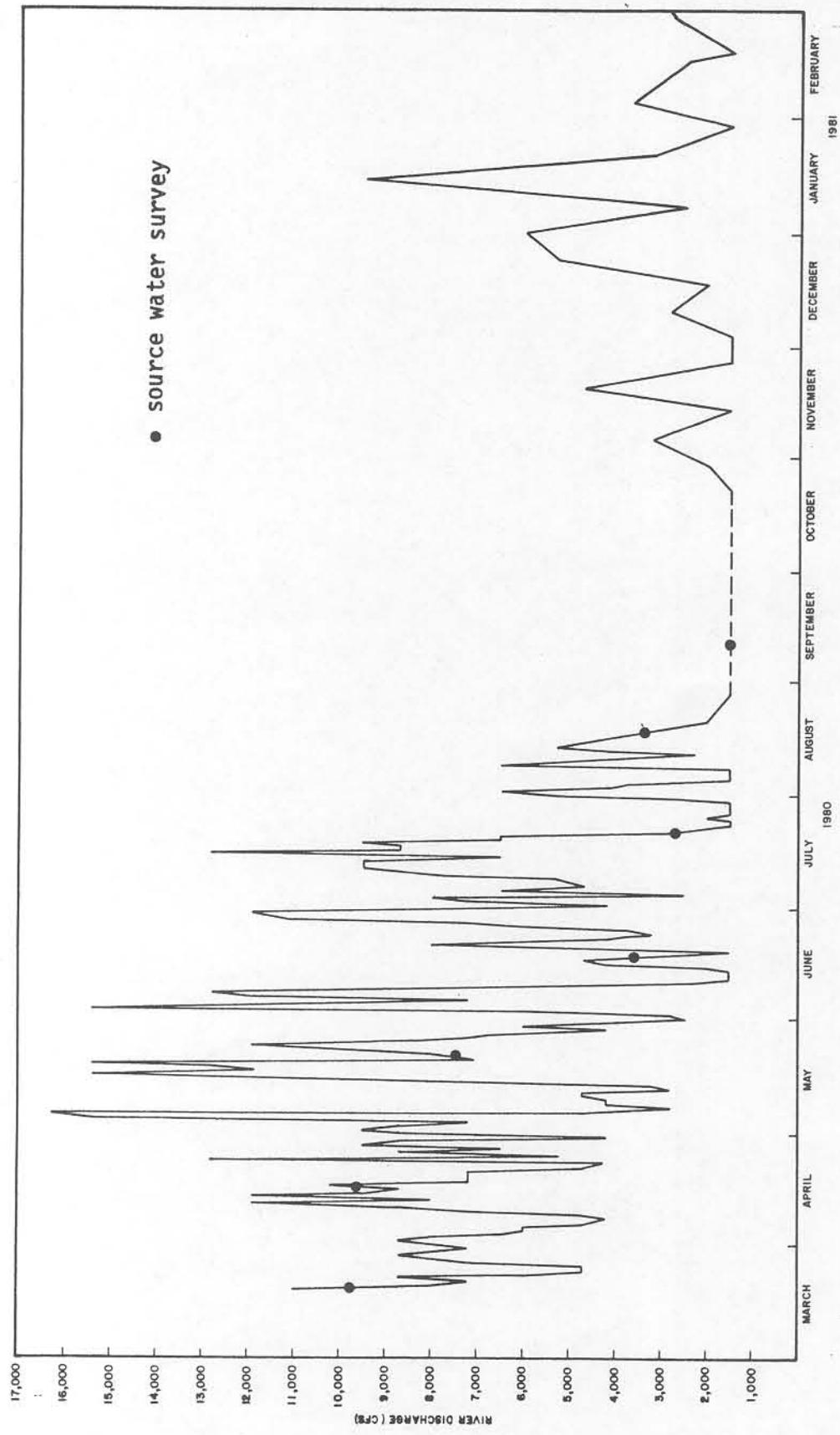


Figure 7. White River flows during the survey year, 1980-1981. Dots indicate source water survey date. NOTE: Flow obtained from river stage information. Conversion factors below 1500 cfs not available.

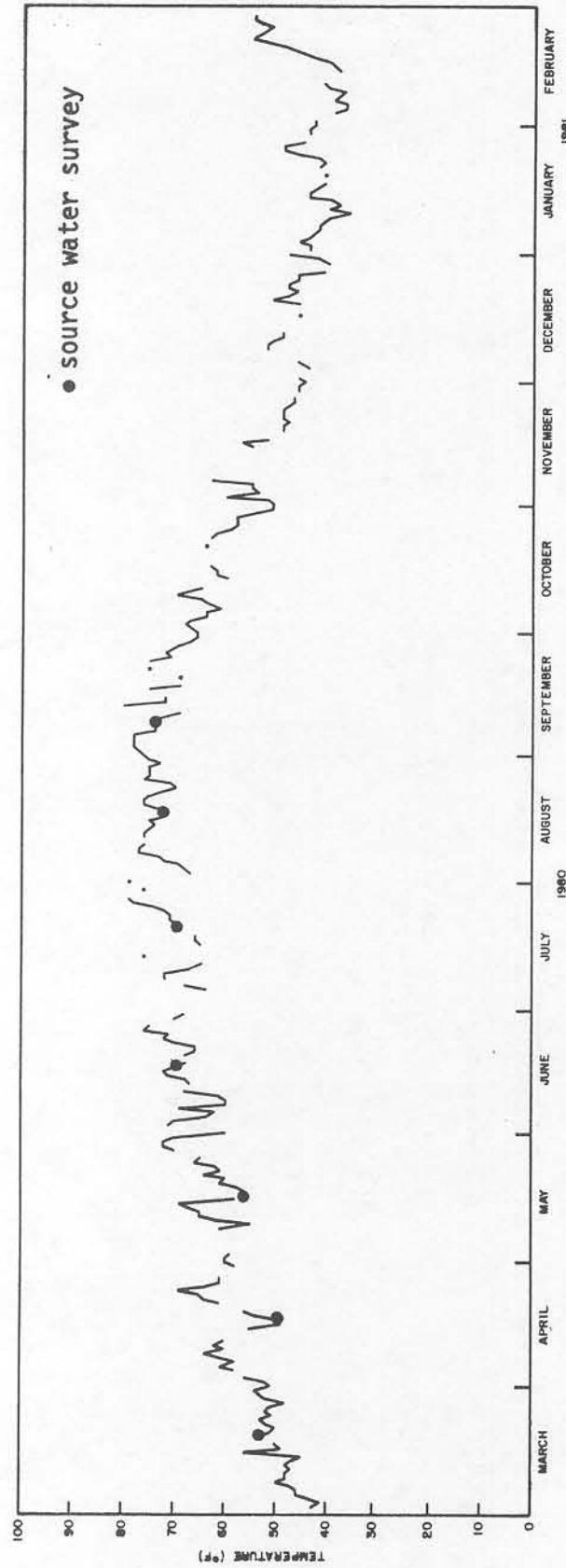


Figure 8. Water temperatures measured daily at the plant throughout the survey, 1 March 1980 through 16 February 1981. Dots indicate survey date.

flow, low water temperature, and lack of suitable solid substrates, all a result of effects of upstream dams. Low diversity and small population size of macroinvertebrates were also attributed to the adverse effects of upstream dams. The benthic insect fauna appeared to be affected by loss of acceptable habitats due to fluctuations in river level. Backwater pools and other littoral areas which were left exposed during low flows, and habitats such as debris and submerged wood carried away during high flows are examples of such losses.

V. METHODOLOGY

A. Sampling Strategy

The sampling methodology for the Arkansas Eastman 316b program consisted of essentially four parts. These are as follows:

- 1) in-plant impingement sampling;
- 2) in-plant fish eggs and larvae and macroinvertebrate drift sampling;
- 3) source water fish eggs and larvae and macroinvertebrate drift sampling;
- 4) source water hydrology and bathymetry survey.

The sampling frequency for the above tasks was scheduled such that an accurate estimate of the annual impingement and entrainment rates could be computed as well as a comparison made between entrainment mortality and source water populations. Sampling for impingement was performed on a weekly basis for a one year period beginning 19 March 1980 and ending 11 March 1981. In-plant entrainment sampling was run concurrent with the impingement sampling on a weekly basis during the fish spawning season only. Sampling was initiated on 19 March 1980 and lasted through 17 September 1980. Source water sampling was also performed during the fish spawning season and was performed on a monthly basis beginning 19 March 1980 and ending 17 September 1980.

All in-plant sampling (both entrainment and impingement) was performed by Arkansas Eastman personnel. Monthly source water sampling was performed by Geo-Marine, Inc. During these field visits, biologists reviewed the impingement and entrainment programs run by plant personnel and verified the catch.

Before sampling began on 19 March 1980, an arrangement was made by which the operation of the intake structure, on the days of survey, would simulate the impact of a higher flow rate. First, one of two intake pipes was blocked with stop logs so that the velocity of water flowing through the unblocked pipe would double (see Figure 5). In addition, instead of one circulating pump operating as under present normal operations, two 8,000 gpm pumps were operated on the day of each survey. The net result was that in terms of intake velocity, the impingement impact simulated the impact of four times the present velocity rate under normal operation (from 0.32 to 1.26 fps).

In-plant entrainment was performed via a 4-inch pipe that was tapped into the main circulating water pipe at a point just after the circulating pump. It was assumed that turbulent flow occurred in the lines, especially near the discharge point of the pumps and that a representative sample would be taken if an adequate volume of water was removed during the sampling. The water from the tap-in was filtered through a standard 0.5 m plankton net (505μ mesh) suspended in a 55 gallon drum which was set in a circular steel tank (radius and height of 2.5 ft.). A 90° V-notch weir was inserted and sealed into a cutout section in the side of the tank for measurement of head height. Flow rate was then computed according to Barnes formula:

$$Q = 2.48 H^{2.48}$$

where:

Q = flow rate in cfs

H = head height in ft.

Ichthyoplankton generally exhibit highly clumped or patchy distributions and little is known about patch size or frequency of occurrence (Krause and Van Den Aryle 1979⁷). Fish larvae are known to exhibit diel patterns of distribution and often more are entrained at night (Jude 1977⁸). In order to account for possible diel differences of abundance, both a day and night sample was taken on each survey date.

B. Procedures

1. Impingement

The impingement sampling was performed once per week for a 24 hour period. The procedure for each sampling was as follows:

- 1) At a specified time each week, both 8,000 gpm circulating pumps were put into operation.
- 2) The two revolving screens were completely washed of all debris by placing on manual wash for one revolution.
- 3) A collection basket constructed of 1/4" hardware cloth was placed in the wash water box so that all debris and fish were caught.
- 4) The revolving intake screens were periodically washed during the 24 hour period. All fish were removed and placed in sealed buckets; samples were preserved in 5 percent formalin.
- 5) At the end of 24 hours, the screens were washed and the final sample collected.
- 6) Collections were transported to Geo-Marine, Inc.'s Richardson, Texas laboratory for measurement and identification. A survey log of the sampling dates, intake velocity and circulating water pump rates appears in Table 1.

2. Entrainment

a. Fish Eggs and Larvae and Macroinvertebrate Drift

Fish eggs and larvae were collected on the same day as the impingement sampling from 19 March 1980 through 17 September 1980. Samples were collected during a two hour period in the daytime (about 1200-1400) and over a two hour period at night (about 2200-2400). The procedure was as follows:

- 1) The tank with a 55 gallon drum was placed under the water tap.
- 2) The valve on the tap was adjusted so that between 13 and 18 cm of head height was obtained.
- 3) The larval fish net was placed under the tap for two hours.
- 4) After two hours, the sample was removed, preserved in 5 percent formalin, and transported to Geo-Marine, Inc.'s Richardson, Texas laboratory for identification, enumeration and sizing.

Table 1
Survey Log - Impingement

Date	Sample Time	Pump Rate (gpm)	Intake Velocity* (fps)
19-20 March 1980	1345-1345	10,000	0.79
26-27 March 1980	0850-0850	12,000	0.94
2-3 April 1980	0830-0830	13,000	1.02
9-10 April 1980	0940-0940	13,000	1.03
16-17 April 1980	0900-0900	13,000	1.02
24-25 April 1980	1100-1100	16,000	1.26
1-2 May 1980	0830-0830	16,000	1.26
7-8 May 1980	0900-0900	16,000	1.26
14-15 May 1980	0900-0900	16,000+	1.26+
21-22 May 1980	0900-0900	16,000+	1.26+
28-29 May 1980	0900-0900	16,000+	1.26+
4-5 June 1980	0900-0900	16,000+	1.26+
11-12 June 1980	0900-0900	16,000+	1.26+
18-19 June 1980	0830-0830	16,000+	1.26+
25-26 June 1980	0900-0900	16,000+	1.26+
2-3 July 1980	0900-0900	16,000+	1.26+
10-11 July 1980	0900-0900	16,000+	1.26+
17-18 July 1980	CIRCULATING	PUMP DOWN FOR REPAIR	
23-24 July 1980	0830-0830	16,000+	1.26+
30-31 July 1980	0900-0900	16,000+	1.26+
6-7 August 1980	0900-0900	16,000	1.26
13-14 August 1980	0900-0900	16,000	1.26
20-21 August 1980	0900-0900	16,000	1.26
27-28 August 1980	0900-0900	16,000	1.26
3-4 September 1980	0900-0900	9,600	0.76
10-11 September 1980	0900-0900	9,600	0.76
17-18 September 1980	0900-0900	16,000	1.26
24-25 September 1980	0900-0900	16,000	1.26
1-2 October 1980	0900-0900	16,000	1.26

*Based on clean pipe with 28.3 sq. ft. cross section

Table 1 (cont'd)
Survey Log - Impingement

Date	Sample Time	Pump Rate (gpm)	Intake Velocity* (fps)
8-9 October 1980	0900-0900	15,500	1.22
15-16 October 1980	0900-0900	16,000	1.26
22-23 October 1980	0900-0900	16,000	1.26
29-30 October 1980	0900-0900	15,200	1.20
6-7 November 1980	0900-0900	15,300	1.20
13-14 November 1980	0900-0900	15,600	1.23
19-20 November 1980	0900-0900	15,300	1.20
26-27 November 1980	0900-0900	14,500	1.14
3-4 December 1980	0900-0900	15,600	1.23
10-11 December 1980	0900-0900	14,400	1.13
17-18 December 1980	0900-0900	14,600	1.15
24-25 December 1980	0900-0900	14,200	1.12
31 December 1980- 1 January 1981	0900-0900	14,400	1.13
7-8 January 1981	0900-0900	14,000	1.10
14-15 January 1981	0900-0900	14,000	1.10
21-22 January 1981	0900-0900	14,700	1.16
28-29 January 1981	0900-0900	15,400	1.21
4-5 February 1981	0900-0900	14,800	1.17
16-17 February 1981	0800-0800	15,800	1.24
18-19 February 1981	0800-0800	15,700	1.24
27-28 February 1981	0800-0800	15,000	1.18
4-5 March 1981	0900-0900	14,200	1.12
11-12 March 1981	0800-0800	14,600	1.15

*Based on clean pipe with 28.3 sq. ft. cross section

- 5) At the laboratory, the sample was stained for five minutes in a 1 percent solution of rose bengal to facilitate sorting.⁹ It was then rinsed and placed in a pan to hand sort the macroinvertebrates and larval fish. All organisms were identified to the lowest positive taxon and expressed as individuals/10 m³. Fish larvae were measured to the nearest 0.1 mm total length and results expressed as length range for each species on each sampling date. A log for the entrainment sampling appears in Table 2.

b. Zooplankton

One zooplankton sample was collected per month during the survey period. A zooplankton net (153 μ mesh) was placed under the water tap after the day ichthyoplankton sample was completed. The water was allowed to run at the same rate for 15 minutes. The sample was collected and preserved in 5 percent formalin and transported to the Richardson, Texas laboratory for identification and enumeration.

Each sample was split into two samples using a Folsom plankton splitter. One half of the sample was placed into a counting wheel and all organisms counted under a dissecting scope. Identification was made by removing representative individuals of each species and placing them on a glass slide containing 10 percent glycerin. They were examined under a compound scope at 400x magnification¹⁰, identified to the lowest positive taxon and expressed as organisms/m³. If counts became excessive, further splits were made to facilitate sorting and identification.

c. Phytoplankton

A one liter phytoplankton sample was taken monthly from the water tap-in. The sample was preserved with 10 ml of Lugol's solution and transported to the Richardson, Texas, laboratory for identification and enumeration. A survey log for both zooplankton and phytoplankton appears in Table 3.

At the laboratory, phytoplankton were counted and identified to the lowest positive taxon using an inverted microscope at 600x magnification. Plankton were allowed to settle after placing in a tube chamber. Two to four lateral strips were examined across the bottom of the chamber and the counted area determined. Algal forms identified were then expressed as # organisms/ml.¹¹

Table 2
In-Plant Survey Log - Larval Fish and Macroinvertebrates

Date	Sample Time	Pump Rate (gpm)	Weir Height (cm)	Volume Filtered (m ³)
19 March 1980	1530-2102	10,000	13.2	63.4
	2102-2302	10,000	12.5	55.4
26 March 1980	1255-1455	12,000	13.0	61.1
	1910-2110	12,000	12.9	59.9
2 April 1980	1250-2110	13-14,000	12.8	58.8
	2110-2310	13-14,000	13.0	61.1
9 April 1980	1135-1335	13,000	13.1	61.1
	2030-2230	13,000	13.0	61.0
16 April 1980	1140-1340	13,000	13.0	61.1
	2040-2240	13,000	12.8	58.8
24 April 1980	1100-1300	16,000	13.0	61.1
	2030-2230	16,000	13.0	61.1
1 May 1980	1150-1350	16,000	13.0	61.1
	2100-2300	16,000	13.0	61.1
7 May 1980	1045-1245	16,000	13.0	61.1
	2100-2300	16,000	13.0	61.1
14 May 1980	1100-1300	16,000+	13.0	61.1
	2040-2240	16,000+	13.0	61.1
21 May 1980	1045-1245	16,000+	13.0	61.1
	2110-2310	16,000+	13.0	61.1
28 May 1980	1110-1310	16,000+	18.0	136.9
	2100-2300	16,000+	17.5	136.9
4 June 1980	1105-1305	16,000+	18.0	136.9
	2030-2230	16,000+	18.0	136.9
11 June 1980	1310-1510	16,000+	18.0	136.9
	N I G H T	S A M P L E	M I S S E D	
18 June 1980	1100-1300	16,000+	18.0	136.9
	2000-2200	16,000+	18.0	136.9
25 June 1980	1105-1305	16,000+	18.0	136.9
	2000-2200	16,000+	18.0	136.9
2 July 1980	1050-1250	16,000+	18.0	136.9
	2030-2230	16,000+	18.0	136.9
10 July 1980	1045-1255	16,000+	19.0	169.5
	2100-2300	16,000+	18.0	136.9
17 July 1980	C I R C U L A T I N G	P U M P	D O W N	F O R
		R E P A I R S		

NOTE: Flow meter for pump rate scaled to 16,000 gpm. Measured rates exceeding this value indicated by +.

Sample volume increased on 28 May to insure a more representative sample.

Table 2 (cont'd)
In-Plant Survey Log - Larval Fish and Macroinvertebrates

Date	Sample Time	Pump Rate (gpm)	Weir Height (cm)	Volume Filtered (m ³)
23 July 1980	1105-1305	16,000+	19.0	156.5
	2030-2230	16,000+	19.0	156.5
30 July 1980	1110-1310	16,000+	19.0	156.5
	2030-2230	16,000+	19.0	156.5
6 August 1980	1125-1330	16,000	19.0	150.0
	2000-2200	16,000	19.0	156.5
13 August 1980	1200-1400	16,000	19.0	156.5
	2000-2200	16,000	19.0	156.5
20 August 1980	1200-1400	16,000	19.0	156.5
	2000-2400	16,000	19.0	156.5
27 August 1980	1150-1350	16,000	19.0	156.5
	2000-2200	16,000	19.0	156.5
3 September 1980	1200-1400	9,600	19.0	156.5
	2011-2211	9,600	19.0	156.5
10 September 1980	1230-1430	9,600	18.0	136.9
	2000-2200	9,600	19.0	156.5
17 September 1980	1130-1330	16,000	19.0	156.5
	2000-2200	16,000	19.0	156.5

NOTE: Flow meter for pump rate scaled to 16,000 gpm. Measured rates exceeding this value indicated by +.

Table 3
Survey Log - Zooplankton (sampling volume) and Phytoplankton

Date	Time	Weir Height (cm)	Volume Filtered (m ³)
19 March 1980	1733-1748	13.3	8.08
9 April 1980	1345-1400	13.1	7.78
14 May 1980	1310-1325	13.0	7.63
18 June 1980	1300-1315	18.0	17.11
23 July 1980	1425-1440	19.0	19.56
20 August 1980	1430-1445	19.0	19.56
17 September 1980	1340-1355	19.0	19.56
22 October 1980	1300-1315	20.0	22.22
19 November 1980	1320-1335	18.0	17.11
17 December 1980	1230-1245	19.0	19.56
14 January 1981	1310-1325	19.0	19.56
16 February 1981	1330-1345	19.0	19.56

NOTE: Sample volume increased on 18 June to insure a more representative sample.

For more complete identification of diatoms, a portion of each sample was oxidized in a solution of potassium dichromate to clean the organic debris from the diatom frustules. Permanent diatom slides were prepared and analyzed at 1000x magnification using a species proportional count method.^{12,13}

3. Source Water Fish Eggs and Larvae and Macroinvertebrate Drift

A source water sampling program was carried out to estimate standing crops of macroinvertebrates and larval fish. This information was necessary to assess the level of impact of the plant on these two important source water components.

Ichthyoplankton and macroinvertebrate drift were sampled with one meter diameter plankton nets at the surface and near bottom at a near-field station, and at the surface at mid- and far-river stations (Figure 9). The survey log for source water sampling of larval fish and macroinvertebrate drift is shown in Table 4.

4. Source Water Hydrology and Bathymetry

From April through September, hydrological and bathymetric measurements were made in the intake canal and at each of the three source water sampling sites by Geo-Marine, Inc. Depth was measured using a Ratheon Model DE-7198 200 KHz recording fathometer. A cross river transect was made from the intake pipe to the opposite shore of the river. During the September survey, a more accurate depth profile was made of the intake canal by measuring the depth with a steel tape at 5 ft. horizontal intervals.

An Endeco Type 110 current meter was used to measure current speed and direction at 5 ft. depth intervals at the source water stations and directly in front of the intake pipe.

VI. RESULTS AND DISCUSSION

A. Phytoplankton

Phytoplankton are susceptible to entrainment and possible damage in cooling water systems such that rates of mortality, growth, reproduction and primary production are affected. In most cases, effects are of short duration and are confined to a relatively small portion of the water body segment.¹ The effect on a population is usually proportional to the percent of river flow that is taken in by the plant

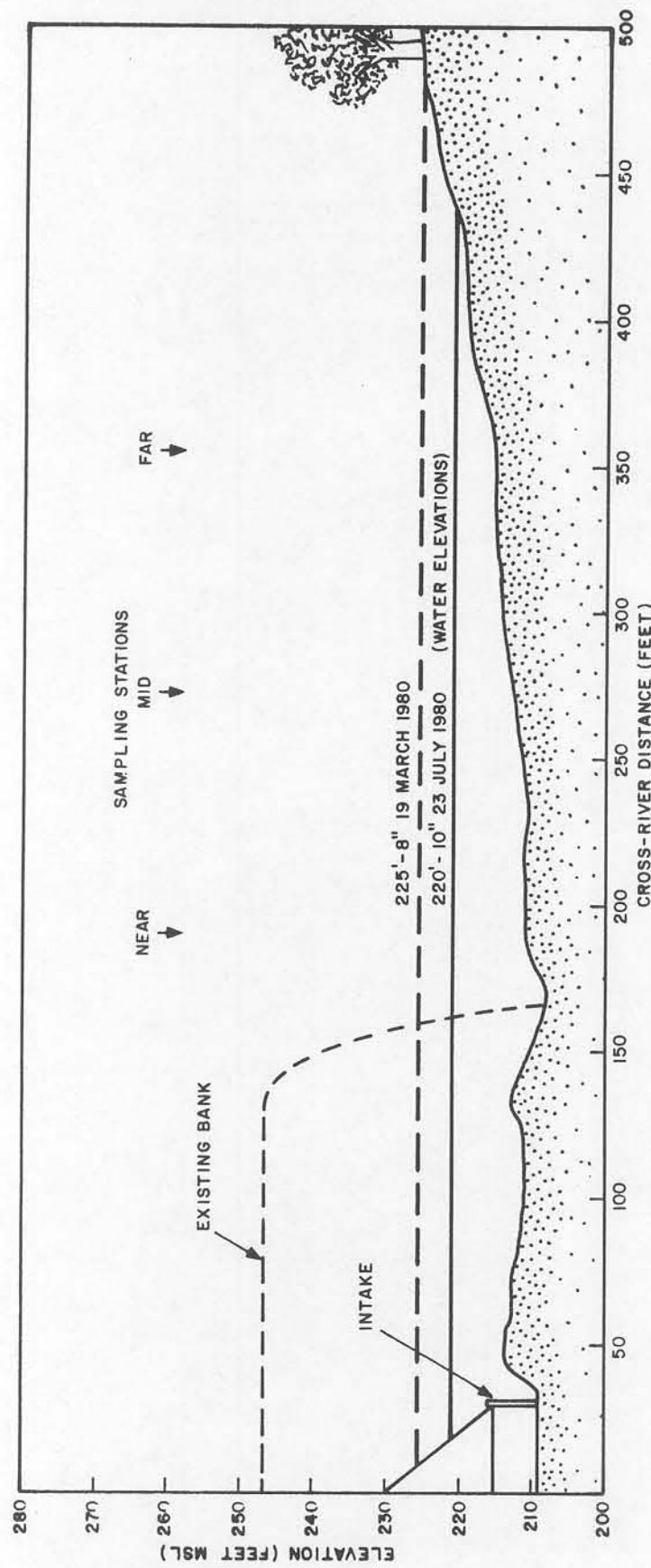


Figure 8. Location of sampling stations on the White River and water elevations during the highest and lowest river stage on dates surveyed.

Table 4
Source Water Survey Log - Larval Fish and Macroinvertebrates

Date	Time	Station (station-depth)	Volume Filtered (m ³)
19 March 1980	1600-1700	Near-Surface	212.1
		Near-Bottom	85.1
		Mid-Surface	207.6
		Far-Surface	209.6
	2130-2230	Near-Surface	229.8
		Near-Bottom	145.9
		Mid-Surface	247.4
		Far-Surface	96.6
16 April 1980	1300-1400	Near-Surface	190.8
		Near-Bottom	71.4
		Mid-Surface	158.7
		Far-Surface	165.2
	2100-2200	Near-Surface	181.7
		Near-Bottom	117.8
		Mid-Surface	215.9
		Far-Surface	100.3
21 May 1980	1130-1230	Near-Surface	232.0
		Near-Bottom	92.8
		Mid-Surface	170.7
		Far-Surface	211.1
	2100-2200	Near-Surface	224.1
		Near-Bottom	197.0
		Mid-Surface	186.9
		Far-Surface	112.5
18 June 1980	1230-1330	Near-Surface	225.0
		Near-Bottom	109.5
		Mid-Surface	178.2
		Far-Surface	143.6
	2100-2200	Near-Surface	173.3
		Near-Bottom	132.2
		Mid-Surface	173.3
		Far-Surface	145.3
23 July 1980	1230-1330	Near-Surface	175.8
		Near-Bottom	132.2
		Mid-Surface	171.0
		Far-Surface	125.2

Table 4 (cont'd)

Source Water Survey Log - Larval Fish and Macroinvertebrates

Date	Time	Station (station-depth)	Volume Filtered (m ³)
23 July 1980	2115-2215	Near-Surface	173.4
		Near-Bottom	128.6
		Mid-Surface	155.2
		Far-Surface	83.8
20 August 1980	1225-1325	Near-Surface	161.8
		Near-Bottom	168.1
		Mid-Surface	166.8
		Far-Surface	157.8
	2200-2300	Near-Surface	193.9
		Near-Bottom	148.3
		Mid-Surface	165.2
		Far-Surface	150.8
11 September 1980	1200-1300	Near-Surface	103.7
		Near-Bottom	87.4
		Mid-Surface	158.5
		Far-Surface	104.1
	1930-2030	Near-Surface	187.1
		Near-Bottom	136.9
		Mid-Surface	151.1
		Far-Surface	141.2

and also to the uniqueness or special importance of the species assemblage at a particular site.

The results of the monthly sampling for phytoplankton at the Arkansas Eastman Plant are shown in Appendix A. The species assemblage is very diverse with 87 taxa identified. Of these 87 taxa, 64 were pennate diatoms. During most of the months sampled, pennate diatoms were the most abundant species in the collections. The majority of these species were ones that are common in the attached algal communities of streams (e.g., Navicula, Synedra, Nitzschia, Achnanthes and Cocconeis) (Hynes 1970¹⁴). During higher river flows, cells from the attached communities are washed from the substrate and become planktonic.

Total densities of phytoplankton ranged from 7,068.6 cells/ml in March to 327.3 cells/ml in April. The high counts in March were the result of a bloom of Chroococcus minor which made up 89 percent of the sample. It is a blue-green species that grows with dense clots of miscellaneous algae or on aquatic plants. Higher flows again probably were responsible for the high incidence of this species in the sample.

The impact on the phytoplankton community by the Eastman Plant is deemed to be low. At low river flows of 1,500 cfs and higher than normal pump rates of 16,000 gpm and 32,000 gpm, the plant would use only 2.4 and 4.8 percent, respectively, of the river flow for its operation. The resultant impact on the phytoplankton assemblage, due to its regenerative capacity, is presently and would most likely under higher pump rates remain negligible.

B. Zooplankton

Most zooplankton are incapable of sustained mortality against water flow and drift passively in the currents; therefore, they are also susceptible to entrainment. Studies have shown the zooplankton composition to be the same at the discharge as at a point 20 miles upstream, indicating they were uniformly entrained (Brauer et al. 1974¹⁵). As with the phytoplankton, intake effects on zooplankton populations are of relatively short duration and are confined to small portions of the water body. Zooplankton normally have a short life span and large regenerative capacity. The impact of entrainment on a population may be dependent on the percent of river flow withdrawn for cooling, distribution of zooplankton and entrainment losses (Rogers 1978¹⁶). Increases in zooplankton volume have been attributed to seeding

bypassing the plant followed by accelerated reproduction in the warm, mixed river (Coutant 1970¹⁷).

The results of the zooplankton sampling at the Arkansas Eastman Plant are shown in Appendix B. Cladocera and copepoda dominated the samples. Cladocera ranged in density from $30.85/m^3$ in April to $0.09/m^3$ in October. Copepoda ranged from $18.71/m^3$ in June to $0.51/m^3$ in August. (Protozoa and rotatoria were essentially excluded from the sample due to the 153μ mesh net used in the sampling.) The total densities found were quite low and agree with other studies that zooplankton constitute a relatively small proportion of the aquatic biomass in fluvial systems (Greenburg 1964¹⁸, Reinhard 1931¹⁹).

Species occurring in the greatest numbers between March and June were typical of flowing river systems (Chydorus sphaericus and Bosmina longirostris) (Whittton 1975²⁰). Other species encountered are more typical of lake populations and were probably transients from drainage basin lakes, ponds or backwaters.

As with the phytoplankton, the impact of the Arkansas Eastman Plant appears to be negligible. This is due to the low percent of river water taken in by the plant at present rates (1.2 percent) and under higher than normal rates of 16,000 gpm (2.4 percent) and 32,000 gpm (4.8 percent) and due to the very low zooplankton biomass found in the intake water.

C. Macroinvertebrate Drift

Samples collected to determine the entrainment impact on macroinvertebrate drift in the White River consisted of in-plant samples taken simultaneously with the in-plant larval fish samples, and source water samples at three stations and two depths taken simultaneously with the larval fish samples. To determine diel patterns in both the larval fish and macroinvertebrate entrainment rate, both day and night sampling was performed. These results are shown in Appendix C.

Thirty-three genera of drifting macroinvertebrates were found in the in-plant and source water samples at or near the Arkansas Eastman Plant between April and August 1980 (Table 5). Dipterans (flies, mosquitoes, and midges), tricopterans (caddis flies) and ephemeropeterans (mayflies) made up 75.3 percent, 10.8 percent and 4.6 percent of the source water samples, respectively, while the same orders made up 51.5 percent, 8.1 percent and 23.6 percent, respectively, of the in-plant samples

Table 5

Taxonomic Listing of Macroinvertebrate Organisms
Found in In-Plant and Source Water Samples
Collected April - August 1980

Phylum Coelenterata
Class Hydrozoa
Genus Hydra americana

Phylum Annelida
Class Oligochaeta
Genus Nais simplex

Phylum Arthropoda
Class Crustacea
Subclass Branchipoda
Order Cladocera
Subclass Malacostraca
Order Isopoda
Genus Lirceus brachyurus
Order Amphipoda
Genus Allocrangonyx sp.
Subclass Copepoda

Class Insecta
Order Collembola
Suborder Arthropleona
Superfamily Entomobryoidea
Family Isotomidae

Order Ephemeroptera
Family Caenidae
Genus Caenis sp.
Family Baetidae
Genus Baetis sp.
Family Heptageniidae
Genera Stenonema sp.
Heptagenia sp.
Family Ephemerellidae
Genus Ephemerella sp.
Family Leptophlebiidae
Genus Paraleptophlebia sp.
Family Ephemeridae
Genus Hexagenia sp.

Order Odonata
Suborder Zygoptera
Family Coenagrionidae
Genus Argia sp.

Order Plecoptera
Suborder Filipalpia
Family Nemouridae
Genus Nemoura sp.
Suborder Setipalpia
Family Perlidae
Genus Perlesta placida

Table 5 (cont'd)

Taxonomic Listing of Macroinvertebrate Organisms
Found in In-Plant and Source Water Samples
Collected April - August 1980

- Order Hemiptera
 - Family Gerridae
 - Genus Gerris sp.
 - Family Corixidae
 - Family Macroveliidae
 - Genus Macrovelia sp.
 - Family Hydrometridae
- Order Tricoptera
 - Family Philopotamidae
 - Genera Chimarra obscura
Chimarra sp.
 - Family Hydropsychidae
 - Genera Hydropsyche sp.
Cheumatopsyche sp.
 - Family Limnephilidae
 - Genus Pycnopsyche sp.
 - Family Hydroptilidae
 - Genus Hydroptila sp.
 - Family Leptoceridae
 - Genus Leptocerus sp.
 - Family Psychomiidae
 - Genus Neuraclipsis sp.
- Order Coleoptera
 - Family Elmidae
 - Family Hydrophilidae
 - Genus Berosus sp.
 - Family Gyrinidae
 - Genus Gyrinus sp.
 - Family Psphenidae
 - Genus Ectoparia nervosa
 - Family Dytiscidae
 - Genus Coptotomus sp.
 - Family Staphylinidae
- Order Diptera
 - Suborder Nematocera
 - Superfamily Tipuloidea
 - Family Tipuloidea
 - Genus Tipula sp.
 - Superfamily Culicoidea
 - Family Chironomidae (Tendipedidae)
 - Subfamily Chironominae
 - Tribe Chironomini
 - Tribe Macropellopini
 - Tribe Tanytarsini
 - Genus Simulium venustum

Table 5 (cont'd)

Taxonomic Listing of Macroinvertebrate Organisms
Found in In-Plant and Source Water Samples
Collected April - August 1980

Family Culicidae
Subfamily Culicinae
Genus Chaoborus sp.
Family Simuliidae
Subfamily Simuliinae
Genus Metacnephia sp.
Suborder Brachycera
Superfamily Tabanoidea
Family Tabanidae
Genus Tabanus sp.
Superfamily Empidoidea
Family Empididae
Genus Hemerodromia sp.
Family Stratiomyidae
Family Ephydriidae

(Table 6). Individuals of the family ephemeroptera (mayflies) occurred in higher percentage of total population in the source water samples as compared to the in-plant samples. Members of this family are more maneuverable than dipterans and are herbivorous. The combination of maneuverability and dietary requirements of shallow, algae covered areas probably leads to this variation in distribution.

The highest mean day-night macroinvertebrate density occurred on the 16 April source water survey (3.82 per 10 m³) while densities of between 2.00 and 2.93 per 10 m³ were common in the April, May, June and July samples. August samples showed lower densities which generally were below 1.00 per 10 m³.

Drifting macroinvertebrates are made up of the following types: (1) behavioral drift--occurring at night, or other consistent period of day, resulting from a behavioral pattern characteristic of a certain species; (2) catastrophic drift--resulting from the physical disturbance of the bottom fauna, usually by flood and consequent bottom scouring; and (3) constant drift--occurring at all times and in low numbers with a continuous stream of representatives of several species (Waters 1972²¹). The macroinvertebrate drift of the White River at the Eastman Plant appears to be primarily behavioral, since a diel periodicity was usually exhibited with a higher density occurring in the night samples. This difference was shown to be significant in both the in-plant and source water samples (Table 7). Although in-plant samples showed higher densities than near station source water densities, they did not vary significantly from the mean of all source water stations. The distribution also followed a seasonal emergence pattern with the highest densities occurring in the summer months (May, June and July).

The impact of the plant on the macroinvertebrate population of the White River was assessed by estimating the standing crop of macroinvertebrate drift passing the plant on each source water survey date and comparing it to the number of drift organisms entrained by the plant as estimated by the in-plant sample densities. The error factor of this calculation was computed by finding the confidence interval around each mean. It was estimated that 3.009 ± 0.904 million drift organisms were entrained by the plant during the months of April through August (Table 8). By comparison, it is estimated that 418.350 ± 125.611 million drift organisms passed by the plant during the same months (Table 9). By using the

Table 6

Macroinvertebrate Taxon Ranking in the In-Plant
and Source Water Samples Taken April - August 1980

Taxon	In-Plant Rank	%	Source Water Rank	%
Coelenterata	10	0.2	4	5.3
Annelida	4	4.3	5	2.7
Isopoda	5	1.6	-	0.0
Amphipoda	8	0.6	6	2.5
Collembola	-	0.0	10	0.7
Ephemeroptera	3	4.6	2	23.6
Odonata	11	0.1	-	0.0
Plecoptera	9	0.4	7	2.1
Hemiptera	7	0.8	9	1.6
Tricoptera	2	10.8	3	8.1
Coleoptera	6	1.3	8	2.0
Diptera	1	<u>75.3</u>	1	<u>51.5</u>
TOTAL		100.0		100.0

Table 7
Macroinvertebrate Statistical Comparisons
Wilcoxon Signed Rank Test²²

Test	Probability Level	Conclusion
Daytime = Nighttime densities (in-plant)	.005	nighttime densities are greater
Daytime = Nighttime densities (source water)	.005	nighttime densities are greater
In-Plant = Source Water densities (all stations)	NS	no difference
In-Plant = Source Water densities (near station only)	.025	in-plant densities are greater

NS = not significant

Table 8
In-Plant Macroinvertebrate Entrainment

Month	Plant Pump Rate gpm (10 m ³ /sec)	Mean In-Plant Density* No/10 m ³ ± CI**	No. Entrained*** Per Month No. ± CI (10 ⁶)
March	16,000 (0.101)	1.745 ± 1.166	0.472 ± 0.315
April	16,000 (0.101)	3.753 ± 0.720	0.983 ± 0.188
May	16,000 (0.101)	1.852 ± 0.502	0.501 ± 0.136
June	16,000 (0.101)	2.217 ± 0.563	0.580 ± 0.147
July	16,000 (0.101)	1.556 ± 0.350	0.421 ± 0.095
August	16,000 (0.101)	0.194 ± 0.082	<u>0.052 ± 0.022</u>
			3.009 ± 0.904

*Mean of all day and night macroinvertebrate densities recorded during month (see Appendix C-1, exuvia not included).

**CI = 95 percent confidence interval; Std dev/ \sqrt{N}

***ENT = PR x ED x C

where: ENT = number entrained per month

PR = pump rate in 10 m³/sec (158,475 gpm)

ED = mean in-plant entrainment density

C = conversion factor (number of seconds per month)

Table 9
Source Water Macroinvertebrate Density

Month	River Flow cfs (10 m ³ /sec)	Source Water Density* No./10 m ³ ± CI**	Standing Crop Passing Plant*** Per Month No. ± CI** (10 ⁶)
March	11,000 (31.14)	0.714 ± 0.407	59.551 ± 33.946
April	10,200 (28.88)	4.009 ± 0.978	300.102 ± 73.210
May	8,000 (22.65)	0.680 ± 0.186	41.253 ± 11.284
June	1,500 (4.25)	0.476 ± 0.295	5.244 ± 3.250
July	1,500 (4.25)	0.615 ± 0.198	7.001 ± 2.254
August	2,000 (5.66)	0.343 ± 0.110	5.200 ± 1.668
			418.350 ± 125.611

*Mean density of day and night; near, mid and far stations macroinvertebrate densities recorded during survey (see Appendix C-2, exuvia not included).

**CI = 95 percent confidence interval; Std dev/ \sqrt{N}

***SC = RF x SD x C

where: SC = standing crop passing plant per month

RF = river flow in 10 m³/sec (353.4 cfs)

SD = mean source water density

C = conversion factor (number of seconds per month)

extremes of these ranges, between 0.4 and 1.3 percent and more probably near 0.7 percent of the macroinvertebrate drift population was entrained by the Arkansas Eastman Plant during these months. At this low percentage at 16,000 gpm or at double the percentage at 32,000 gpm, the impact by the plant on the macroinvertebrate fauna of the White River is judged to be minimal.

D. Fisheries

The methods used to estimate the impact of plant operation on the White River fish population included impingement sampling, in-plant entrainment sampling and source water ichthyoplankton sampling. In addition, during June of the survey year, the Arkansas Game and Fish Department performed source water fish sampling in the area around the plant intake and discharge. A species list compiled of the fish collected during these surveys is presented in Table 10. A total of 30 species of fish representing 11 families plus one reptile were collected by all the aforementioned sampling methods.

1. Fish Eggs and Larvae

In-plant and source water ichthyoplankton sampling was performed from mid-April through mid-September 1980. There were 7 species representing 6 families found in the in-plant samples while 19 species representing 9 families were found in the source water samples. Results are given in Appendix D. The species makeup of the source water and in-plant samples showed very different trends. The most numerous family found in the in-plant samples was the cyprinids (minnows) at 51.7 percent, while the most numerous family found in the source water samples was catostomids (suckers) at 64.3 percent. The percids (perches) ranked second in both samples while the catostomids and cyprinids ranked third, respectively, in the in-plant and source water samples (Table 11).

Both fish eggs and larvae first appeared in the source water samples on the 16th of April. Larvae first appeared in the in-plant samples on 7 May, with the first eggs appearing 14 May. Eggs continued to appear in both the in-plant and source water samples during May but dropped off in number during June. In the July and August source water samples, large densities of eggs appeared but were not matched by large densities in the in-plant samples nor followed by the appearance of larvae in the August and September in-plant and source water sampling. Densities of larval fish reached a peak in the source water samples during the 18 June night

Table 10

Species List of Fish and Reptile Caught from the White River
at and near the Arkansas Eastman Plant

Scientific Name	Common Name	Entrainment	Source Water	Impingement	State Survey
Petromyzontidae	Lampreys	X	X	X	X
<u>Ichthyomyzon</u> sp.	Lamprey species				
<u>Ichthyomyzon</u> <u>castaneus</u>	Chestnut lamprey	X	X	X	X
Acipenseridae	Sturgeons				
Lepisosteidae	Gars				
<u>Lepisosteus</u> <u>oculatus</u>	Spotted gar				
<u>Lepisosteus</u> <u>osseus</u>	Longnose gar				
<u>Lepisosteus</u> <u>platosomus</u>	Shortnose gar				
Ciliupeidae	Herrings				
Dorosoma <u>cepedianum</u>	Gizzard shad	X	X	X	X
Dorosoma <u>petenense</u>	Threadfin shad				
Dorosoma spp.	Shad species				
Hiodontidae	Mooneyes				
<u>Hiodon</u> <u>tergisus</u>	Mooneye	X	X	X	X
Cyprinidae	Minnows	X	X	X	X
<u>Cyprinus</u> <u>carpio</u>	Carp				
<u>Hybopsis</u> sp.	Chub species				
<u>Notropis</u> <u>atherinoides</u>	Emerald shiner				
<u>Notropis</u> <u>boops</u>	Bigeye shiner				
<u>Notropis</u> <u>whipplei</u>	Steelcolor shiner				
<u>Notropis</u> sp.	Shiner species	X	X	X	X
Catostomidae	Suckers				
<u>Cariodes</u> <u>carpio</u>	River carpsucker				
<u>Cariodes</u> <u>cyprinus</u>	Quillback				
<u>Erimyzon</u> sp.?	Chubsucker species				
Ictiobinae	Buffalo/carpsucker				
<u>Ictiobus</u> <u>bubalus</u>	Smallmouth buffalo				
<u>Ictiobus</u> <u>cyprinellus</u>	Bigmouth buffalo				
<u>Ictiobus</u> <u>niger</u>	Black buffalo				
<u>Moxostoma</u> <u>duquesnei</u>	Black redhorse				
<u>Moxostoma</u> <u>erythrurum</u>	Golden redhorse	X			

Table 10 (cont'd)

Species List of Fish and Reptile Caught from the White River
at and near the Arkansas Eastman Plant

Scientific Name	Common Name	Entrainment	Source Water	Impingement	State Survey
Centrarchidae					
<u>Lepomis humilis</u>	Sunfish	X			
<u>Lepomis macrochirus</u>	Orangespotted sunfish		X		
<u>Lepomis megalotis</u>	Bluegill		X		X
<u>Lepomis</u> sp.	Longear sunfish	X	X		X
<u>Micropodus punctulatus</u>	Sunfish species		X		X
<u>Micropodus salmoides</u>	Spotted bass		X		X
<u>Micropodus</u> sp.	Largemouth bass		X		X
<u>Pomoxis nigromaculatus</u>	Bass species		X		X
Percidae	Black crappie		X		X
	Perches	X	X		
Etheostominae	Darter species		X		
<u>Etheostoma</u> sp.	Darter species		X		X
<u>Etheostoma caeruleum</u>	Rainbow darter		X		X
<u>Percina</u> sp.	Darter species	X			
<u>Stizostedion canadense</u>	Sauger				
<u>Stizostedion vitreum</u>					
Vitreum	Walleye				
Sciariidae	Drums				
<u>Aplochitonus grunniens</u>	Freshwater drum				X
Cottidae	Sculpins				
<u>Cottus carolinae</u>	Banded sculpin	X		X	
<u>Graptemys pseudogeographica</u>					
<u>v. ouachitensis</u>	Ouachita map turtle			X	

Table 11

Ranking and Percent Make-Up of the Larval Fish
 Families Found in the In-Plant and Source Water Sampling
 April - September 1980

Family	In-Plant Rank	%	Source Water Rank	%
Petromyzontidae (Lampreys)	5	1.5	7	0.5
Acipenseridae (Sturgeons)	5	1.5	7	0.5
Clupeidae (Herrings)	-	0.0	4	4.0
Hiodontidae (Mooneyes)	-	0.0	7	0.5
Cyprinidae (Minnows)	1	51.7	3	9.2
Catostomidae (Suckers)	3	14.0	1	64.3
Centrarchidae (Sunfish)	4	6.9	5	3.8
Percidae (Perches)	2	24.4	2	16.6
Cottidae (Sculpins)	-	<u>0.0</u>	6	<u>0.6</u>
TOTAL		100.0		100.0

sampling ($1.60/10\text{ m}^3$), while the peak occurred in-plant on the 7 May night sampling ($1.3/10\text{ m}^3$). As with the total rankings, cyprinids dominated the in-plant samples while catostomids dominated the source water samples. These peaks are associated with river temperatures of 58°F and 68°F , respectively. Larval fish densities in this reach of the White River are extremely low as compared to other larger rivers in which densities above $10/10\text{ m}^3$ are not unusual.^{23,24}

Patterns of distribution and abundance were tested statistically in the same manner as the macroinvertebrate drift. No difference in in-plant and source water densities was shown, nor was there any difference between in-plant and near station densities (Table 12). The only test performed that showed significance was the day-night source water densities, with larger densities occurring at night. This same trend was not noted however with the in-plant sampling which showed no difference between day and night larval fish densities.

The size distribution of the larvae showed that very few larvae collected in both in-plant and source water samples were over 10 mm in length. This suggests that as is shown in other studies (Connors 1976²⁵) that mid-channel habitats are not optimal for the larvae of most freshwater species and that larger larvae are usually found in near shore tributary habitats. This suggests that riverine larvae fish species either move quickly out of mid-channel environments and/or suffer heavy mortality there with increasing larval size.

As with the macroinvertebrate drift information, the impact of the plant on the larval fish population of the White River was assessed. The standing crop of larval fish passing the plant on each source water survey date was compared to the number of larvae entrained by the plant as estimated by the in-plant sample densities. The error factor of this calculation was computed by finding the confidence interval around each mean. It was estimated that 0.255 ± 0.166 million larvae were entrained by the plant during 1980 (Table 13). By comparison, it was estimated that 36.992 ± 13.465 million larvae passed by the plant in the White River during the same period (Table 14). By using the extremes of these ranges, between 0.2 and 1.8 percent and more probably near 0.7 percent of the larval fish population was entrained.

The entrainment rate of fish eggs and larvae is a function of both intake volume and intake velocity. At the earliest stages of development (egg and early protolarval), intake volume is the principle determinant of entrainment rates. But, as the larvae

Table 12
Larval Fish Statistical Comparisons
Wilcoxon Signed Rank Test²²

Test	Probability Level	Conclusion
Daytime = Nighttime densities (in-plant)	NS	no difference
Daytime = Nighttime densities (source water)	.005	nighttime densities are greater
In-Plant = Source Water densities (all stations)	NS	no difference
In-Plant = Source Water densities (near station only)	NS	no difference

NS = not significant

Table 13
In-Plant Larval Fish Entrainment

Month	Plant Pump Rate gpm (10 m ³ /sec)	Mean In-Plant Density* No./10 m ³ ± CI**	No. Entrained Per Month*** No. (10 ⁶) ± CI**
March	16,000 (0.101)	0.000 ± 0.000	-
April	16,000 (0.101)	0.000 ± 0.000	-
May	16,000 (0.101)	0.438 ± 0.158	0.118 ± 0.043
June	16,000 (0.101)	0.261 ± 0.050	0.068 ± 0.013
July	16,000 (0.101)	0.160 ± 0.068	0.043 ± 0.018
August	16,000 (0.101)	0.095 ± 0.054	0.026 ± 0.015
September	16,000 (0.101)	0.000 ± 0.000	-
			0.255 ± 0.166

*Mean of all day and night in-plant larval fish densities recorded during month (see Appendix D-1).

**CI = 95 percent confidence interval; Std dev/ \sqrt{N}

***ENT = PR x ED x C

where: ENT = number entrained per month

PR = pump rate in 10 m³/sec (158,475 gpm)

ED = mean in-plant entrainment density in No./10 m³

C = conversion factor (number of seconds per month)

Table 14
Source Water Larval Fish Densities

Month	River Flow cfs (10 m ³ /sec)	Source Water Density* No./10 m ³	Standing Crop Passing Plant Per Month*** No. CI**(10 ⁶)
March	11,000 (31.14)	0.000 ± 0.000	-
April	10,200 (28.88)	0.160 ± 0.077	11.977 ± 5.764
May	8,000 (22.65)	0.236 ± 0.051	14.317 ± 3.094
June	1,500 (<4.25)	0.845 ± 0.383	9.309 ± 4.219
July	1,500 (<4.25)	0.114 ± 0.034	1.298 ± 0.387
August	2,000 (5.66)	0.006 ± 0.006	0.091 ± 0.091
September	1,500 (<4.25)	0.000 ± 0.000	-
			36.992 ± 13.465

*Mean density of day and night; near, mid and far stations (see Appendix D-2)
larval fish densities recorded during month

**CI = 95 percent confidence interval; Std dev/ \sqrt{N}

***SC = RF x SD x C

where: SC = standing crop passing plant per month

RF = river flow in 10 m³/sec (353.4 cfs)

SD = mean source water density

C = conversion factor (number of seconds per month)

obtain swimming ability during the later stages of development, intake velocity becomes a greater determinant of entrainment rates. The entrainment rates observed during the sampling year were reflective of an intake rate of somewhere between 16,000 and 32,000 gpm depending upon the stage of development of the fish larvae and their susceptibility to either intake volume or velocity. At an intake rate of 32,000 gpm, the expected cropping rate of fish larvae would fall between 0.7 and 1.4 percent of the larval fish population.

For the purpose of impact analysis, it is assumed that there is 100 percent mortality of organisms entrained by the plant. Recent studies have indicated that the mortality rate can be somewhat less than 100 percent depending upon the characteristics of the specific plant and characteristics of the faunal assemblage of the source water (Jensen 1978²⁶). However, since lengthy studies are required at a particular plant to determine the mortality factor, it is practical to assume a worse case condition of 100 percent mortality so that an assessment of the maximum impact can be made.

The removal of 0.255 million larval fish from the population can be put into perspective by assigning a conservative age specific natural mortality factor to the population, then advancing the "cohort" to adult age, here defined as Age II. This then allows one to evaluate entrainment mortality in terms of "equivalent adults", or the number of adults that would be removed from the population. At a conservative survival rate of 0.1 percent of larvae reaching Age II adults, the estimated annual larval entrainment represents about 255 adult fish, a number which is low compared to population densities in the White River (Arkansas Fish & Game Dep. 1980⁴).

2. Juvenile and Adult Fish

Weekly impingement sampling was conducted between 19 March 1980 and 11 March 1981; results are presented in Table 15. In 51 surveys, only eleven fish and one reptile (turtle) weighing a total of 1969.5 grams (4.3 lbs) were impinged. These figures can be expanded to estimate the total annual impingement. This results in an estimate of 85 fish and reptiles weighing 14.1 kg (31.0 lbs) impinged per year. Since these rates were measured at velocity rates reflecting 32,000 gpm, no significant changes in impingement rates can be expected at an actual intake rate of 32,000 gpm.

Table 15
Impingement Results

Date	Taxon	Standard Length (mm)	Weight (g)
19-20 March 1980	-		
26-27 March 1980	-		
2-3 April 1980	Longear sunfish	125	42.0
9-10 April 1980	-		
16-17 April 1980	-		
24-25 April 1980	-		
1-2 May 1980	-		
7-8 May 1980	-		
14-15 May 1980	-		
21-22 May 1980	-		
28-29 May 1980	Chestnut lamprey	285	59.4
4-5 June 1980	-		
11-12 June 1980	Gizzard shad	156	47.8
18-19 June 1980	-		
25-26 June 1980	Banded sculpin	110	23.4
	Gizzard shad	230	217.8
2-3 July 1980	-		
11-12 July 1980	-		
17-18 July 1980	-		
23-24 July 1980	-		
30-31 July 1980	-		
6-7 August 1980	-		
13-14 August 1980	-		
20-21 August 1980	-		
27-28 August 1980	-		
3-4 September 1980	-		
10-11 September 1980	Longear sunfish	100	31.9
17-18 September 1980	-		
24-25 September 1980	-		

Table 15 (cont'd)

Impingement Results

Date	Taxon	Standard Length (mm)	Weight (g)
1-2 October 1980	-		
8-9 October 1980	-		
15-16 October 1980	-		
22-23 October 1980	-		
29-30 October 1980	-		
6-7 November 1980	-		
13-14 November 1980	-		
19-20 November 1980	Ouachita map turtle	99*	125.5
	Carp	391	1263.0
26-27 November 1980	-		
3-4 December 1980	-		
10-11 December 1980	-		
17-18 December 1980	-		
24-25 December 1980	-		
31 December 1980- 1 January 1981	-		
7-8 January 1981	-		
14-15 January 1981	-		
21-22 January 1981	-		
28-29 January 1981	-		
4-5 February 1981	-		
16-17 February 1981	-		
18-19 February 1981	Longear sunfish	115	30.3
	Longear sunfish	115	30.6
	Longear sunfish	145	75.6
27-28 February 1981	-		
4-5 March 1981	-		
11-12 March 1981	Longear sunfish	108	22.2
Total Number = 11 fish; 1 reptile			
Total Weight = 1969.5 grams (4.3 lbs)			

*Carapace length

These low numbers are in sharp contrast to the standing crop of resident species as indicated by the Arkansas Game and Fish Department survey on 24-25 June 1980. A total of 407 fish weighing 216.7 lbs were recovered from two daytime and two nighttime electroshocking attempts.⁴ Twenty-four species from nine families were collected. Gizzard shad accounted for 70.5 percent of the fish collected, with catostomids (suckers) comprising the majority of the remaining fish caught (see Table 11).

E. Hydrological Measurements

During each site visit to the Arkansas Eastman Plant by Geo-Marine, Inc. personnel, measurements of the intake canal and source water current speed and direction were made; results are shown in Table 16. Due to the varying current regimes in the intake canal, the current speed and direction were measured directly in front of the intake pipe only. During the June, July and August surveys, this was successfully completed and flow velocities ranged from 1.4 to 1.9 fps. This is somewhat higher than the theoretical velocity of 1.3 fps for a 72" conduit with 16,000 gpm flow, but it is probably due to partial silting in front of the pipe as suggested by the bathymetric measurements (see Figure 8).

Source water current directions were generally in a direction of 100° to 110° from the north with little if any deflection toward the intake canal noticed at the near station (90° from the north experienced at 5 and 10 ft. depths on 23 July). The highest current velocities were generally at the mid-station, ranging from 1.3 fps at low flow to 3.9 fps during high flows. Slightly lower velocities were seen at the near station with much lower velocities seen at the far station (0.2 to 1.4 fps) (see Table 16).

VII. CONCLUSIONS AND ECOSYSTEM RATIONALE

As defined in the 316(b) draft guidelines¹, adverse aquatic environmental impacts occur whenever entrainment or impingement damage results due to operation of a specific cooling water intake structure. The magnitude of any adverse impact is the critical question. This magnitude should be estimated in regards to long- and short-term impacts in reference to absolute damage (numbers of aquatic organisms impinged or entrained per month or year); percent damage (percent of aquatic organisms in existing populations impinged or entrained, respectively); absolute and percent damage to endangered species or critical aquatic organisms; absolute

Table 16

Flow Velocity Measurements Taken During Field Surveys

Location-Depth	16 April	21 May	Flow Velocity (fps)/Flow Direction (degrees)			11 September*
			18 June	23 July	20 August	
INTAKE-surface bottom (5'-7')	0.3/320 0.3/320**	0.3/345 0.5/330**	0.2/180 1.9/345	0.2/322 1.8/22.5	0.2/10 1.4/20	-
NEAR -surface 5 ft. 10 ft.	2.2/105 2.5/110 -	3.2/105 3.5/105 3.2/105	1.9/110 2.0/110 1.9/110	0.9/100 1.0/90 1.0/90	2.4/105 2.2/105 2.2/108	0.8/110 0.8/105 0.5/100
MID -surface 5 ft. bottom (7'-9')	3.9/110 3.5/110	3.2/105 3.4/110 3.2/105	2.3/105 2.2/110 2.0/110	1.5/112 1.3/120 1.3/110	2.5/110 2.5/110 2.2/110	2.4/115 2.0/112 1.9/112
FAR -surface	1.4/110	1.4/105	0.4/110	0.2/100	0.7/110	0.3/135
River Discharge	10,200 cfs	8,000 cfs	<1,500 cfs	<1,500 cfs	2,000 cfs	1,500 cfs
Plant Pump Rate	12,600 gpm	16,000 gpm	16,000 gpm	16,000 gpm	16,000 gpm	-
Temperature	11.2°C/52°F	17.5°C/64°F	18.3°C/65°F	21.9°C/71°F	24.0°C/75°F	22.0°C/72°F

*Main circulating pumps down for repairs.

**Due to initial difficulty in placing flow meter in front of intake pipe, the velocity was not accurately measured.

and percent damage to commercially valuable and/or sport fisheries yield; or whether the impact would endanger (jeopardize) the protection and propagation of a balanced population of shellfish and fish in and on the body of water from which the cooling water is drawn (long-term impact).

Entrainment of phytoplankton and zooplankton by the Arkansas Eastman Plant was not shown to be of a level that would result in any impact on the resident plankton populations. Reduced numbers of zooplankton species and biomass are characteristic of permanent, swift-water streams (Whitton 1975²⁰). The maximum density recorded was 30.85/m³ for cladocera, which is very low. At an intake rate of 2.4 percent of the White River low flow, phytoplankton and zooplankton populations are essentially unaffected.

Very low involvement with macroinvertebrates, fish eggs and larvae was also demonstrated. The cropping rate for macroinvertebrates was calculated to be only 0.7 percent. A total of 25 fish eggs was entrained during the year. Also, small numbers of larval fish were entrained and a low cropping rate of 0.9 percent was calculated. Total larval fish mortality due to entrainment represents the removal of about 255 Age II adult fish from the population per year using equivalent age adult factor to the number of fish larvae entrained. These numbers indicate negligible impact on the source water populations.

Despite intake velocities of up to 1.9 fps, impingement rates were extremely low. Only one turtle and 11 fish were impinged during 51 24-hour surveys which represents very minor involvement with the source water adult fishery.

It is concluded that the design and placement of the Arkansas Eastman Plant's intake canal, conduits and traveling screen structure leads to low impingement rates even though standing crops of adult fish, that are normal for a river the size of the White River, exist in the area. Entrainment rates of planktonic biota are also low when compared to standing crops existing in the river. The data set provided demonstrates that the continued operation of the Arkansas Eastman Plant, at the tested rate (16,000 gpm), is not creating adverse impacts to the local aquatic populations. It also shows that at higher intake velocities (representing a 32,000 gpm intake through two conduit pipes), minimal impingement rates are maintained.

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APPENDIX A
In-Plant Phytoplankton Sampling Results

Appendix A

In-Plant Phytoplankton Sampling Results

Species	Mar. Org/ml	Apr. Org/ml	May Org/ml	June Org/ml	July Org/ml	Aug. Org/ml
<u>Chlorophyta</u>						
<u>Chlamydomonas</u> sp.						
<u>Closterium</u> sp.						
<u>Falcatus</u> var. <u>mirabilis</u>						
<u>Kirchneriella</u> <u>Tunaris</u>						
<u>Quadrigula</u> <u>Lacustris</u>						
<u>Scenedesmus</u> <u>acuminatus</u>						
<u>Sphaerocystis</u> <u>schoeteri</u>						
Total	104.7 117.8	0.0	6.5	6.5	6.5	13.1 6.5
<u>Chrysophyta</u>						
<u>Cryptomonas</u> <u>erosa</u>						
<u>Cryptomonas</u> <u>ovata</u>						
<u>Dinobryon</u> <u>divergens</u>						
<u>Rhodomonas</u> <u>lacustris</u>						
Total	0.0	0.0	0.0	13.0	45.8	0.0
<u>Bacillariophyta</u>						
<u>Centrales</u>						
<u>Cyclotella</u> <u>glomerata</u>						
<u>Cyclotella</u> <u>menghiniana</u>						
<u>Cyclotella</u> <u>stelligera</u>						
<u>Melosira</u> <u>ambigua</u>						
<u>Melosira</u> <u>distans</u> var. <u>alpigena</u>						
<u>Melosira</u> <u>granulata</u>						
<u>Melosira</u> <u>varians</u>						
<u>Stephanodiscus</u> <u>astraea</u>						
<u>Stephanodiscus</u> <u>niagarae</u>						
Total	157.1	91.6	65.5	58.9	45.8	45.8

Appendix A (cont'd)

In-Plant Phytoplankton Sampling Results

Species	Mar. Org/ml	Apr. Org/ml	May Org/ml	June Org/ml	July Org/ml	Aug. Org/ml
Bacillariophyta						
Pennales						
Achnanthes <u>lanceolata</u> var. <u>dubia</u>	2.4	4.6	8.6	5.9	6.5	19.6
Achnanthes <u>minutissima</u>	46.1	3.4	20.6	20.6	5.2	28.6
Amphora <u>ovalis</u>	9.7	3.4	6.9	7.4		16.6
Amphora <u>veneta</u>						1.5
Caloneis <u>ventricosa</u>						1.5
Cocconeis <u>diminuta</u>						1.5
Cocconeis <u>pediculus</u>						1.5
Cocconeis <u>placentula</u> var. <u>euglypta</u>	118.9	60.6	96.3	1.5	2.6	15.1
Cocconeis <u>placentula</u> var. <u>lineata</u>				25.1	25.9	12.1
Cocconeis <u>placentula</u>						
Cocconeis <u>scutellum</u>						
Cymatopleura <u>solea</u>						
Cymbella <u>affinis</u>						
Cymbella <u>lata</u>						
Cymbella <u>mexicanum</u>						
Cymbella <u>minuta</u>	82.5	66.3	154.8	95.8	7.8	6.0
Cymbella <u>sinuata</u>		4.9			1.3	3.0
Cymbella <u>tumida</u>		12.1	1.1		4.4	
Cymbella <u>turgida</u>					4.4	
Diatoma <u>anceps</u>	19.4	2.3	1.7	22.1		
Diatoma <u>hiemale</u>						
Diatoma <u>tenue</u>						
Diatoma <u>vulgare</u>	26.7	11.4	8.6	14.7	155.3	9.0
Fragilaria <u>capucina</u>	24.3	19.4		2.9		28.6
Fragilaria <u>construens</u>	26.7	1.1	20.6	10.3	9.1	24.1
Frustulia <u>crotensis</u>						
Frustulia <u>rhombooides</u>						
Frustulia <u>vulgaris</u>						
Gomphonema <u>grovei</u>				1.1		

Appendix A (cont'd)
In-Plant Phytoplankton Sampling Results

Species	Mar. Org/ml	Apr. Org/ml	May Org/ml	June Org/ml	July Org/ml	Aug. Org/ml
Bacillariophyta						
Pennales (cont'd)						
<u>Gomphonema olivaceum</u>	7.3	3.4	1.7	22.1	19.4	12.1
<u>Gomphonema sphaerophorum</u>						
<u>Gomphonema truncatum</u>						
<u>Gomphonema ventricosum</u>						
<u>Gyrosigma acuminatum</u>						
<u>Gyrosigma scalpoides</u>						
<u>Meridion circulare</u>	12.1					
<u>Navicula capitata</u>						
<u>Navicula decussata</u>						
<u>Navicula exigua</u>						
<u>Navicula radiosa</u>						
<u>Navicula rhynchocephala</u>						
<u>Navicula salinarum</u> var. <u>intermedia</u>						
<u>Navicula viridula</u>						
Navicula sp.						
<u>Nedium dubium</u>						
<u>Nitzschia acicularis</u>						
<u>Nitzschia dissipata</u>	17.0	10.3	1.7	2.3	1.7	2.9
<u>Nitzschia filiformis</u>						
<u>Nitzschia palea</u>						
<u>Nitzschia paradoxa</u>						
<u>Nitzschia sigmaidea</u>						
<u>Opephora martyi</u>						
<u>Rhoicosphenia curvata</u>						
<u>Rhopalodia gibba</u>						
<u>Surirella angustata</u>						
<u>Surirella linearis</u>						
<u>Surirella ovalis</u>						
<u>Surirella ovata</u> var. <u>pinnata</u>						
	2.4	1.1	1.7	1.1	1.3	3.0

Appendix A (cont'd)

In-Plant Phytoplankton Sampling Results

Species	Mar. Org/ml	Apr. Org/ml	May Org/ml	June Org/ml	July Org/ml	Aug. Org/ml
Bacillariophyta Pennales (cont'd)						
<u>Synedra acus</u>	2.4		1.7	1.5		
<u>Synedra amphicephala</u>				4.4	2.6	12.1
<u>Synedra ulna</u> var. <u>oxyrhynchus</u>		5.7			3.9	16.6
<u>Synedra ulna</u>					1.3	
<u>Synedra vaucheriae</u>						
<u>Tabellaria flocculosa</u>						
Total	432.0	2.3	405.8	327.3	353.4	418.9
Bacillariophyta						
TOTAL	589.1	327.2	471.3	386.2	399.2	464.7
Cyanophyta						
<u>Chroococcus limneticus</u>						
<u>Chroococcus minor</u>	6283.2					
<u>Oscillatoria</u> sp.	78.5	0.0	0.0		144.0	0.0
Total	6361.7				144.0	
GRAND TOTAL	7068.6	327.3	477.8	432.0	608.6	582.5

Appendix A (cont'd)

In-Plant Phytoplankton Sampling Results

Species	Sept. Org/ml	Oct. Org/ml	Nov. Org/ml	Dec. Org/ml	Jan. Org/ml	Feb. Org/ml
<u>Chlorophyta</u>						
<u>Chlamydomonas</u> sp.	26.2	13.1		15.7		
<u>Closterium</u> sp.	6.5					
<u>Falcatus</u> var. <u>mirabilis</u>	39.3					
<u>Kirchneriella</u> <u>lunaris</u>						
<u>Quadrigula</u> <u>lacustris</u>						
<u>Scenedesmus</u> <u>acuminatus</u>						
<u>Sphaerocystis</u> <u>schoeteri</u>						
Total	72.0	72.0	0.0	36.6	0.0	0.0
<u>Chrysophyta</u>						
<u>Cryptomonas</u> <u>erosa</u>						
<u>Cryptomonas</u> <u>ovata</u>						
<u>Dinobryon</u> <u>divergens</u>						
<u>Rhodomonas</u> <u>lacustris</u>						
Total	130.9	281.4	13.1	20.8	0.0	0.0
<u>Bacillariophyta</u>						
<u>Centrales</u>						
<u>Cyclotella</u> <u>glomerata</u>	21.8	39.3	53.2	14.7	8.4	2.7
<u>Cyclotella</u> <u>menechtiniana</u>		6.5	31.9	12.8	1.3	4.1
<u>Cyclotella</u> <u>stelligera</u>						
<u>Melosira</u> <u>ambigua</u>	54.5	3.3			4.4	28.4
<u>Melosira</u> <u>distans</u> var. <u>alpigena</u>	21.8	16.4				
<u>Melosira</u> <u>granulata</u>		6.5				
<u>Melosira</u> <u>varians</u>	32.7	26.2		5.5	0.4	2.7
<u>Stephanodiscus</u> <u>astraea</u>					4.0	9.4
<u>Stephanodiscus</u> <u>niagarae</u>					0.9	
Total	130.8	98.2	85.1	36.7	19.4	47.3

Appendix A (cont'd)

In-Plant Phytoplankton Sampling Results

Species	Sept. Org/ml	Oct. Org/ml	Nov. Org/ml	Dec. Org/ml	Jan. Org/ml	Feb. Org/ml
Bacillariophyta						
Pennales						
Achnanthes lanceolata var. <u>dubia</u>	5.1 21.7	3.2 16.0	27.7 4.6	21.4	3.5 91.3	2.4 26.7
Achnanthes <u>minutissima</u>	6.4 1.3	3.2			3.5	
Amphora ovalis						
Amphora <u>veneta</u>						
Caloneis <u>ventricosa</u>						
Cocconeis <u>diminuta</u>	3.8 5.1	16.0	13.8	8.0	200.1	123.9
Cocconeis <u>pediculus</u>						
Cocconeis <u>placentula</u> var. <u>euglypta</u>						
Cocconeis <u>placentula</u> var. <u>lineata</u>	32.0	86.2	69.2	40.2	70.2	14.6
Cocconeis <u>placentula</u>						
Cocconeis <u>scutellum</u>						
Cymatopleura <u>solea</u>	115.1 2.6	63.9 2.6	9.2 4.6	8.0 2.7	7.0 64.3	2.4 63.2
Cymbella <u>affinis</u>						
Cymbella <u>lata</u>						
Cymbella <u>mexicanum</u>						
Cymbella <u>minuta</u>	6.4	1.3	4.6	4.6	4.6	75.3
Cymbella <u>sinuata</u>						
Cymbella <u>tumida</u>						
Cymbella <u>turgida</u>						
Diatoma <u>anceps</u>						
Diatoma <u>hiemale</u>						
Diatoma <u>tenue</u>	97.2	60.7	290.5	37.5	77.2	55.9
Diatoma <u>vulgaris</u>						
Fragilaria <u>capucina</u>	15.3	79.8	69.2	139.3	80.7	17.0
Fragilaria <u>crotonensis</u>					49.1	133.6
Frustulia <u>rhomboides</u>					5.4	
Frustulia <u>vulgaris</u>					4.6	
Gomphonema <u>grovii</u>						

Appendix A (cont'd)

In-Plant Phytoplankton Sampling Results

Species	Sept. Org/ml	Oct. Org/ml	Nov. Org/ml	Dec. Org/ml	Jan. Org/ml	Feb. Org/ml
Bacillariophyta						
Pennales (cont'd)						
<u>Gomphonema olivaceum</u>	15.3	6.4	13.8		52.7	12.2
<u>Gomphonema sphaerophorum</u>						2.4
<u>Gomphonema truncatum</u>	1.3	3.2	13.8		3.5	
<u>Gomphonema ventricosum</u>						
<u>Gyrosigma acuminatum</u>						
<u>Gyrosigma scalpoides</u>	1.3					
<u>Meridion circulare</u>	5.1					
<u>Navicula capitata</u>						
<u>Navicula decussis</u>						
<u>Navicula exigua</u>						
<u>Navicula radiosa</u>						
<u>Navicula rhynchocephala</u>						
<u>Navicula salinarum</u> var. <u>intermedia</u>						
<u>Navicula viridula</u>						
Navicula sp.						
<u>Nedium dubium</u>						
<u>Nitzschia acicularis</u>	3.8					
<u>Nitzschia dissipata</u>						
<u>Nitzschia filiformis</u>	7.7					
<u>Nitzschia palea</u>	3.8	3.2				
<u>Nitzschia paradoxa</u>						
<u>Nitzschia sigmoidea</u>						
<u>Opephora martyi</u>	1.3					
<u>Rhoicosphenia curvata</u>						
<u>Rhopalodia gibba</u>						
<u>Suriella angustata</u>						
<u>Suriella linearis</u>						
<u>Suriella ovalis</u>						
<u>Suriella ovata</u> var. <u>pinnata</u>						

Appendix A (cont'd)

In-Plant Phytoplankton Sampling Results

Species	Sept. 0rg/ml	Oct. 0rg/ml	Nov. 0rg/ml	Dec. 0rg/ml	Jan. 0rg/ml	Feb. 0rg/ml
Bacillariophyta Pennales (cont'd)						
<i>Synedra acus</i>	3.2					
<i>Synedra amphicephala</i>		3.2				
<i>Synedra ulna</i> var. <i>oxyrhynchus</i>	11.5	9.6	18.4	2.7	3.5	4.9
<i>Synedra ulna</i>	12.8				7.0	
<i>Synedra vaucheriae</i>	1.3					
<i>Tabellaria flocculosa</i>	Total	386.2	399.2	608.7	345.6	747.5
Bacillariophyta	TOTAL	517.1	497.4	693.8	382.3	766.9
Cyanophyta						
<i>Chroococcus limneticus</i>					41.9	
<i>Chroococcus minor</i>						
<i>Oscillatoria</i> sp.	Total	117.8	0.0	65.5	41.9	0.0
GRAND TOTAL		864.0	916.3	778.9	492.2	766.9
						550.0

APPENDIX B
In-Plant Zooplankton Sampling Results

Appendix B

In-Plant Zooplankton Sampling Results

Species	Mar. No./m ³	Apr. No./m ³	May No./m ³	June No./m ³	July No./m ³	Aug. No./m ³
Protozoa						
<u>Centropyxis</u> sp.	2.97	2.57	4.19	0.47	3.68	0.0
<u>Diffugia</u>	4.46	2.57	4.19	0.47	3.68	0.0
Rotatoria (rotifers)						
	0.50	0.0	0.0	0.0	0.0	0.0
Cladocera						
<u>Alona costata</u>	4.95	3.60	5.24	1.87	0.41	
<u>Alonella exista</u>						
<u>Bosmina longirostris</u>	8.42	15.94	3.15	12.16	3.27	
<u>Campocercus rectirostris</u>						
<u>Chydorus globosus</u>	10.40	9.77	8.39			
<u>Chydorus sphaericus</u>	0.50					
<u>Cladocera*</u>						
<u>Daphnia parvula</u>	3.47	1.54	3.74	1.64	0.20	
<u>Daphnia</u> spp.			0.47			
<u>Ilyocryptus</u> spp.						
<u>Ilyocryptus acutifrons</u>						
<u>Ilyocryptus sordidus</u>						
<u>Kurzia latissima</u>						
<u>Leydigia quadrangularis</u>						
<u>Pleuroxus denticulatus</u>						
<u>Scapholeberis kingi</u>						
Copepoda						
<u>Calanoida*</u>	28.73	30.85	16.78	0.94	5.32	0.20
<u>Copepoda*</u>						
<u>Cyclopoida*</u>						
<u>Cyclopoida copepodite</u>						
<u>Cyclops bicuspidatus thomasi</u>	4.95					

*damaged

Appendix B (cont'd)

In-Plant Zooplankton Sampling Results

Species	Mar. No./m ³	Apr. No./m ³	May No./m ³	June No./m ³	July No./m ³	Aug. No./m ³
Copepoda (cont'd)						
<u>Cyclops spp.</u>						
<u>Cyclops vernalis</u>	1.49			0.47		0.10
<u>Diaptomus pallidus</u>				2.81		0.10
<u>Diaptomus reighardi</u>				3.74		0.31
<u>Diaptomus spp.</u>						
<u>Eucyclops agilis</u>	0.51	0.51	3.15	0.47	0.82	
<u>Ergasilus sp.</u>	0.51					
<u>Harpacticoida</u>	0.99					
<u>Macrocylops albidus</u>	2.48					
<u>Mesocyclops edax</u>						
Tardigrada	12.88	5.73	13.64	17.58	17.51	
Ostracoda	1.98	2.57	1.05			
Hydracarina	0.50	2.48		2.81	9.41	0.10
				0.94		0.10

Appendix B (cont'd)

In-Plant Zooplankton Sampling Results

Species	Sept. No./m ³	Oct. No./m ³	Nov. No./m ³	Dec. No./m ³	Jan. No./m ³	Feb. No./m ³
Protozoa <i>Centropyxis</i> sp. <i>Difflugia</i>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>
Rotatoria (rotifers)	0.0	0.0	0.0	0.0	0.0	0.0
Cladocera <i>Alona costata</i> <i>Alonella exista</i> <i>Bosmina longirostris</i> <i>Camptocercus rectirostris</i> <i>Chydorus globosus</i> <i>Chydorus sphaericus</i>	0.20	0.23	1.64		11.66	3.27
Cladocera*					0.41	
<i>Daphnia parvula</i>	0.09	0.23		0.20	0.20	0.20
<i>Ilyocryptus</i> spp.					0.41	
<i>Ilyocryptus acutifrons</i>	3.07	0.23			0.82	
<i>Ilyocryptus sordidus</i>					0.41	
<i>Kurzia latissima</i>						
<i>Leydigia quadrangularis</i>						
<i>Pleuroxus denticulatus</i>						
<i>Scapholeberis kingi</i>	<u>3.27</u>	<u>0.09</u>	<u>0.23</u>	<u>0.20</u>	<u>14.93</u>	<u>7.77</u>
Copepoda						
<i>Calanoida*</i>	0.82					
<i>Copepoda*</i>						
<i>Cyclopoida*</i>						
<i>Cyclopoida copepodite</i>						
<i>Cyclops bicuspidatus thomasi</i>	0.61	0.09	2.10	0.82	10.02	5.32

*damaged

Appendix B (cont'd)

In-Plant Zooplankton Sampling Results

Species	Sept. No./m ³	Oct. No./m ³	Nov. No./m ³	Dec. No./m ³	Jan. No./m ³	Feb. No./m ³
Copepoda (cont'd)						
<u><i>Cyclops</i></u> spp.						
<u><i>Cyclops vernalis</i></u>	0.27					
<u><i>Diaptomus pallidus</i></u>	0.41					
<u><i>Diaptomus reighardi</i></u>	1.23	0.36	0.70	0.20	1.64	2.45
<u><i>Diaptomus</i></u> spp.			1.87	1.02	0.82	0.41
<u><i>Eucyclops agilis</i></u>					0.20	
<u><i>Ergasilus</i></u> sp.						
<u><i>Harpacticoida</i></u>						
<u><i>Macrocyclops albidus</i></u>	0.54	1.64	1.43	0.82	1.23	
<u><i>Mesocyclops edax</i></u>		0.47 7.01	0.20 3.67	0.82 15.13		
<u><i>Tardigrada</i></u>	3.07	1.26	7.01	15.13	10.64	
<u><i>Ostracoda</i></u>	0.0	0.0	0.0	0.0	0.0	
<u><i>Hydracarina</i></u>	1.02	0.0	0.0	0.0	0.0	
	0.0	0.36	0.0	0.0	0.0	

APPENDIX C
Macroinvertebrate Sampling Results

1. In-Plant
2. Source Water

Appendix C-1

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
19 March 1980	Day	<u>Paraleptophlebia</u> sp. Unidentified*	nymph nymph	1 (0.16) 1 (0.16) 2 (0.32)
	Night	Chironomini Tabanus sp. Macropeltlopini	larae larae larae	3 (0.47) 1 (0.16) 1 (0.16) 5 (0.79)
	Day	Chironomini Chironomini Dipteran*	larae adult larae	2 (0.32) 1 (0.16) 1 (0.16) 4 (0.64)
	Night	Cheumatopsyche sp. Chironomini Hydropsyche sp. <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u> <u>Stenonema</u> sp. <u>Stenonema</u> sp.	larae larae larae nymph larae nymph adult	1 (0.18) 18 (3.25) 4 (0.72) 1 (0.18) 1 (0.18) 2 (0.36) 2 (0.36) 29 (5.23)
26 March 1980	Day			
	Night			
2 April 1980	Day	Chironomini Hydropsyche sp. <u>Paraleptophlebia</u> sp. Fragments*	larae larae nymph larae	19 (3.23) 4 (0.68) 4 (0.68) 4 (0.68) 31 (5.27)
	Night	Baetidae Chironomini Ephydidae Macropeltlopini	nymph larae larae larae	1 (0.16) 19 (3.11) 1 (0.16) 6 (0.98)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
2 April 1980	Night (cont'd)	<u><i>Nais simplex</i></u> <u><i>Simulium venustum</i></u> Tabanidae Fragments*	larvae larvae nymph	1 (0.16) 3 (0.49) 3 (0.49) 4 (0.65) 38 (6.20)
9 April 1980	Day	Chironomini <u><i>Hydropsyche</i></u> sp.	larvae larvae	5 (0.82) 1 (0.16) 6 (1.00)
	Night	Baetidae Chironomini Chironomini <u><i>Hydropsyche</i></u> sp. <u><i>Macropeltopini</i></u> <u><i>Macropeltopini</i></u> <u><i>Paraleptophlebia</i></u> sp. <u><i>Simulium venustum</i></u> <u><i>Tipula</i></u> sp. Fragments*	nymph pupae larvae larvae larvae adult nymph larvae larvae larvae	1 (0.16) 3 (0.49) 15 (2.46) 3 (0.49) 3 (0.49) 1 (0.16) 1 (0.16) 1 (0.16) 1 (0.16) 7 (1.15) 36 (5.88)
16 April 1980	Day	Chironomini <u><i>Hemerodromia</i></u> sp. <u><i>Hydroptila</i></u> sp. Unidentified*	larvae pupae case larvae	7 (1.15) 5 (0.82) 2 (0.33) 2 (0.33)
	Night	Chironomini <u><i>Hydropsyche</i></u> sp. <u><i>Paraleptophlebia</i></u> sp. <u><i>Pycnopsysche</i></u> sp. <u><i>Tabanus</i></u> sp.	larvae larvae nymph adult larvae	5 (0.85) 1 (0.17) 1 (0.17) 1 (0.17) 2 (0.34) 10 (1.70)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
24 April 1980	Day	Chironomini	pupae	2 (0.33)
		Chironomini	larvae	3 (0.49)
		Hydropsyche sp.	larvae	1 (0.16)
		Macropellopini	larvae	5 (0.82)
		<u>Nais simplex</u>	nymph	4 (0.65)
	Night	<u>Paraleptophlebia</u> sp.	nymph exuvia	2 (0.33)
		<u>Paraleptophlebia</u> sp.	adult	1 (0.16)
		<u>Paraleptophlebia</u> sp.	pupae case	$\frac{1}{3}$ (0.16)
		<u>Pycnopsyche</u> sp.		$\frac{1}{3}$ (0.49)
		Chironomini	larvae	17 (2.77)
1 May 1980	Day	<u>Coptotomus</u> sp.	larvae	17 (2.78)
		<u>Macropellopini</u>	larvae	1 (0.16)
		<u>Macropellopini</u>	pupae	3 (0.49)
		<u>Macropellopini</u>	larvae	3 (0.49)
		<u>Nais simplex</u>	adult	1 (0.16)
	Night	<u>Nemoura</u> sp.	nymph	2 (0.33)
		<u>Paraleptophlebia</u> sp.	nymph	1 (0.16)
		Unidentified*	exuvia	$\frac{1}{1}$ (0.16)
		Chironomini	pupae	3 (0.49)
		Chironomini	larvae	2 (0.33)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
7 May 1980	Day	<i>Chironomini</i> <i>Macropeltopiini</i> <i>Paraleptophlebia</i> sp. <i>Tabanus</i> sp.	larvae larvae nymph larvae	3 (0.49) 1 (0.16) 1 (0.16) 1 (0.16) 6 (0.97)
	Night	<i>Chironomini</i> <i>Macropeltopiini</i> <i>Macropeltopiini</i>	larvae pupae larvae	1 (0.16) 3 (0.49) 21 (3.44) 25 (4.09)
	Day	<i>Allocrangonyx</i> sp. <i>Chironomini</i> <i>Chironomini</i>	adult pupae larvae	1 (0.16) 1 (0.16) 2 (0.33) 4 (0.65)
	Night	<i>Allocrangonyx</i> sp. <i>Berosus</i> sp. <i>Chaoborus</i> sp. <i>Chironomini</i> <i>Chironomini</i> <i>Chironomini</i> <i>Lirceus brachyurus</i> <i>Macropeltopiini</i>	adult larvae larvae pupae larvae adult larvae	1 (0.16) 1 (0.16) 1 (0.16) 2 (0.33) 4 (0.65) 1 (0.16) 1 (0.16) 2 (0.33) 13 (2.11)
14 May 1980	Day			
	Night			
21 May 1980	Day	<i>Berosus</i> sp. <i>Chironomini</i> <i>Macropeltopiini</i>	larvae larvae larvae	1 (0.16) 3 (0.49) 2 (0.33) 6 (0.98)
	Night	<i>Berosus</i> sp. <i>Chironomini</i> <i>Chironomini</i>	larvae pupae larvae	1 (0.16) 1 (0.16) 3 (0.49)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
21 May 1980	Night (cont'd)	<u>Coptotomus</u> sp. <u>Lirceus brachyurus</u> <u>Macropletopiini</u> <u>Naïs simplex</u> <u>Stenonema</u> sp. *	larvae larvae nymph	1 (0.16) 2 (0.33) 14 (2.29) 5 (0.82) 1 (0.16) 28 (4.57)
28 May 1980	Day	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Macropeltopiini</u> <u>Pycnopsche</u> sp. <u>Simulium venustum</u>	adult larvae larvae case larvae	1 (0.07) 6 (0.44) 6 (0.44) 1 (0.07) 1 (0.07) 3 (0.22) 16 (1.17)
	Night	<u>Chaoborus</u> sp. <u>Chironomini</u> <u>Perlestia placida</u> <u>Simulium venustum</u>	larvae larvae nymph larvae	1 (0.08) 6 (0.47) 1 (0.08) 1 (0.08) 9 (0.71)
4 June 1980	Day	<u>Chironomini</u> <u>Hydra americana</u> <u>Naïs simplex</u> <u>Tabanidae</u>	larvae	3 (0.22) 1 (0.07) 1 (0.07) 6 (0.43)
	Night	<u>Allocrangonyx</u> sp. <u>Cheumatopsyche</u> sp. <u>Chimarra</u> sp. <u>Chironomini</u> <u>Corixidae</u> <u>Ectopria nervosa</u> <u>Gyrinus</u> sp.	adult larvae adult larvae adult adult larvae	1 (0.07) 1 (0.07) 4 (0.29) 2 (0.15) 1 (0.07) 1 (0.07) 16 (1.17)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
4 June 1980	Night (cont'd)	<u>Hydropsyche</u> sp. <u>Lirceus brachyurus</u> <u>Macropeltopini</u> <u>Naïs simplex</u>	larvae adult larvae	1 (0.07) 2 (0.15) 6 (0.44) 12 (0.88) 47 (3.43)
11 June 1980	Day	<u>Chaoborus</u> sp. <u>Chironomini</u> <u>Hydropsyche</u> sp. <u>Lirceus brachyurus</u> <u>Macropeltopini</u> <u>Simulium venustum</u>	larvae larvae larvae larvae larvae	1 (0.07) 2 (0.15) 1 (0.07) 3 (0.22) 3 (0.22) 1 (0.07) 11 (0.80)
		SAMPLE MISSED		
18 June 1980	Night Day	<u>Hydropsyche</u> sp. <u>Lirceus brachyurus*</u> <u>Macropeltopini</u> <u>Naïs simplex</u> <u>Simulium venustum</u> Fragments*	larvae larvae larvae larvae larvae	2 (0.15) 2 (0.15) 8 (0.58) 3 (0.22) 2 (0.15) 1 (0.07) 18 (1.32)
		Berosus sp. <u>Chaoborus</u> sp. <u>Chironomini</u> Ephydidae Hemerodromia sp. <u>Hydropsyche</u> sp. <u>Hydropsyche</u> sp. <u>Macropeltopini</u>	larvae larvae larvae adult larvae pupae pupae exuvia larvae pupae	1 (0.07) 2 (0.15) 16 (1.17) 1 (0.07) 1 (0.07) 7 (0.51) 1 (0.07) 2 (0.15) 6 (0.44)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
2 July 1980	Day	<u>Chaoborus</u> sp.	larvae	2 (0.15)
		<u>Cheumatopsyche</u> sp.	larvae	5 (0.37)
		<u>Chironomini</u>	larvae	4 (0.29)
		<u>Hemerodromia</u> sp.	adult	1 (0.07)
		<u>Hydropsyche</u> sp.	larvae	1 (0.07)
	Night	<u>Hydropsyche</u> sp.	larvae exuvia	1 (0.07)
		<u>Macroleptophlebia</u> sp.*	larvae	1 (0.07)
		<u>Paraleptophlebia</u> sp.*	nymph exuvia	1 (0.07)
				— 2 (0.14) —
			adult	— 14 (1.02) —
10 July 1980	Day	<u>Allocrangonyx</u> sp.	adult	1 (0.07)
		<u>Chaoborus</u> sp.	larvae	1 (0.07)
		<u>Cheumatopsyche</u> sp.	larvae	2 (0.15)
		<u>Chironomini</u>	pupae	1 (0.07)
		<u>Chironomini</u>	larvae	11 (0.80)
	Night	<u>Elmidae</u>	adult	1 (0.07)
		<u>Hemerodromia</u> sp.	adult	1 (0.07)
		<u>Hexagenia</u> sp.	nymph exuvia	1 (0.07)
		<u>Hydrometridae</u>	adult	1 (0.07)
		<u>Hydropsyche</u> sp.	larvae	4 (0.29)
10 July 1980	Day	<u>Macrovelia</u> sp.	adult	1 (0.07)
		<u>Nais simplex</u>	larvae	3 (0.22)
		<u>Tabanus</u> sp.	larvae	1 (0.07)
			— 28 (2.02) —	
	Night	<u>Cheumatopsyche</u> sp.	larvae	5 (0.29)
		<u>Chironomini</u>	larvae	4 (0.24)
		<u>Hydropsyche</u> sp.	larvae	4 (0.24)
		<u>Macrovelia</u> sp.*	adult	1 (0.06)
		<u>Pycnopsyche</u> sp.	case	1 (0.06)
10 July 1980	Night	<u>Stratiomyidae</u>	larvae	1 (0.06)
		Unidentified*	adult	— 1 (0.06) —
			— 16 (0.95) —	

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
10 July 1980	Night	<i>Argia translata</i> <i>Berosus</i> sp. <i>Chaoborus</i> sp. <i>Cheumatopsyche</i> sp. <i>Chironomini</i> <i>Corixidae</i> <i>Ephemeralla</i> sp.* <i>Gyrinus</i> sp. <i>Hydropsyche</i> sp. <i>Macropeltopinini</i> <i>Macropeltopinini</i> <i>Metacnephia</i> sp. <i>Metacnephia</i> sp.	nymph larvae larvae larvae adult nymph exuvia larvae larvae pupae larvae pupae larvae	1 (0.07) 1 (0.07) 1 (0.07) 5 (0.37) 9 (0.66) 2 (0.15) 1 (0.07) 1 (0.07) 3 (0.22) 4 (0.29) 3 (0.22) 1 (0.07) 4 (0.29) 1 (0.07)
				— (0.07) <u>35</u> (2.55)
17 July 1980	Day Night	CIRCULATING PUMP DOWN FOR REPAIR		
23 July 1980	Day	<i>Cheumatopsyche</i> sp. <i>Chimarra</i> sp. <i>Chironomini</i> <i>Heptagenia</i> sp. <i>Hydroptilidae</i> <i>Hydroptilidae</i> <i>Lirceus brachyurus</i> <i>Macropeltopinini</i> <i>Metacnephia</i> sp. <i>Nais simplex</i> <i>Pycnopsyche</i> sp.	larvae larvae larvae nymph case larvae larvae larvae larvae larvae case	3 (0.19) 2 (0.13) 9 (0.58) 2 (0.13) 1 (0.06) 1 (0.06) 5 (0.32) 3 (0.19) 1 (0.06)
				— <u>1/2</u> (0.06) <u>27</u> (1.72)

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)	
23 July 1980	Night	<u>Chaoborus</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Ephemeridae</u> <u>Hydropsyche</u> sp.* <u>Lirceus brachyurus</u> <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Metacnephia</u> sp. <u>Nais simplex</u> <u>Paraleptophlebia</u> sp.* <u>Paraleptophlebia</u> sp.*	pupae pupae larvae adult larvae larvae exuvia pupae larvae adult larvae exuvia nymph	1 1 20 2 1 6	(0.06) (0.06) (1.28) (0.13) (0.06) (0.38)
		<u>Lirceus brachyurus</u> <u>Metacnephia</u> sp. <u>Pychnosyche</u> sp.	3 (0.19) 1 (0.06) —4 (0.25)	1 (0.19) 1 (0.06) 50 (3.18)	
30 July 1980	Day	<u>Pychnosyche</u> sp.	adult larvae	2 (0.13) 1 (0.06)	
		<u>Cheumatopsyche</u> sp. <u>Hydropsyche</u> sp. <u>Lirceus brachyurus</u> <u>Macropeltopini</u> <u>Neuracalipsis</u> sp.	—4 (0.25)	1 (0.06) 4 (0.25)	
6 August 1980	Day	<u>Hydropsyche</u> sp.	larvae	1 (0.07)	
	Night	<u>Cheumatopsyche</u> sp. <u>Heptageniidae*</u>	larvae nymph	1 (0.06) 1 (0.06) 2 (0.12)	

*damaged

Appendix C-1 (cont'd)

In-Plant Macroinvertebrate Drift Results

Date	Time	Taxon	Stage	Densities No. (No./10 m ³)
13 August 1980	Day	-	-	
	Night	Baetidae* <u>Cheumatopsyche</u> sp.	nymph larvae	1 (0.06) 1 (0.13) 2 (0.19)
20 August 1980	Day	Ephemeroptera* <u>Hydropsyche</u> sp.	nymph nymph	1 (0.06) 1 (0.06) 2 (0.12)
	Night	<u>Cheumatopsyche</u> sp. Ephemeroptera* <u>Lirceus brachyurus</u>	larvae nymph adult	1 (0.06) 1 (0.06) 1 (0.06) 3 (0.18)
27 August 1980	Day	<u>Chaoborus</u> sp. <u>Macropeltiopini</u>	adult adult	1 (0.06) 1 (0.06) 2 (0.12)
	Night	<u>Cheumatopsyche</u> sp. <u>Chironomini</u> <u>Hydropsyche</u> sp. <u>Macropeltiopini</u> <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u> <u>Unidentified*</u>	larvae larvae larvae larvae larvae adult	2 (0.13) 1 (0.06) 5 (0.32) 1 (0.06) 1 (0.06) 1 (0.06) 12 (0.75)

*damaged

Appendix C-2

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
19 March 1980	Day	NS	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Paraleptophlebia</u> sp. <u>Paraleptophlebia</u> sp.	exuvia pupae nymph exuvia nymph	12 (0.56) 2 (0.09) 1 (0.05) 1 (0.15)
		NB	<u>Allocrangonyx</u> sp. <u>Paraleptophlebia</u> sp.	exuvia nymph	14 (0.65) 8 (0.94) 8 (0.82)
		MS	<u>Allocrangonyx</u> sp. <u>Macroptilopini</u> <u>Paraleptophlebia</u> sp. <u>Stenonema</u> sp. <u>Tipula</u> sp.	exuvia larvae nymph exuvia nymph larvae	21 (1.01) 3 (0.14) 1 (0.05)
		FS	<u>Allocrangonyx</u> sp. <u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Heptagenia</u> sp. <u>Hydra americana</u> <u>Hydropsyche</u> sp. <u>Macroptilopini</u> <u>Macroptilopini</u> <u>Paraleptophlebia</u> sp. <u>Perlestaplacida</u> <u>Simulium venustum</u> <u>Simulium venustum</u>	exuvia adult pupae pupae exuvia adult nymph exuvia larvae pupae pupae exuvia adult nymph exuvia adult larvae larvae exuvia	24 (1.15) 64 (3.05) 14 (0.67) 1 (0.05) 2 (0.10) 28 (1.34)

NS = Near-Surface

NB = Near-Bottom

MS = Mid-Surface

FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
19 March 1980	Day (cont'd)	FS	<u>Simulium venustum</u> <u>Simulium venustum</u>	pupae pupae exuvia	$\frac{2}{271}$ (0.0.10) $\frac{2}{(12.94)}$ 64 (3.09)
	Night	NS	<u>Allocranogonyx</u> sp. <u>Chironomini</u> <u>Corixidae</u> <u>Gyrinus</u> sp. <u>Heptagenia</u> sp. <u>Macropeltoplini</u> <u>Paraleptophlebia</u> sp. <u>Paraleptophlebia</u> sp. <u>Perlestida</u> <u>placida</u> <u>Stenonema</u> sp.	exuvia larvae adult adult nymph larvae nymph nymph exuvia nymph nymph	8 (0.35) 1 (0.05) 1 (0.04) 1 (0.04) 2 (0.09) 1 (0.04) 1 (0.04) 3 (0.13)
NB			<u>Allocrangonyx</u> sp. <u>Dytiscidae*</u> <u>Paraleptophlebia</u> sp.	exuvia larvae nymph exuvia	$\frac{9}{9}$ (0.39) 17 (1.17) $\frac{6}{23}$ (0.41) 1 (0.07)
MS			SAMPLE LOST		
	FS		<u>Allocrangonyx</u> sp. <u>Macropeltoplini</u> <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u> <u>Tipula</u> sp.	exuvia larvae nymph exuvia larvae exuvia larvae exuvia	8 (0.83) 3 (0.31) $\frac{1}{13}$ (0.10) $\frac{1}{(1.34)}$ 2 (0.21)
16 April 1980	Day	NS	<u>Allocrangonyx</u> sp. <u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u>	exuvia adult larvae adult	22 (1.15) 1 (0.05) 1 (0.05) 4 (0.21)

*damaged

FS = Far-Surface MS = Mid-Surface NB = Near-Bottom

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
16 April 1980	Day	NS (cont'd)	<i>Hydropsyche</i> sp. <i>Macropellopini</i> <i>Macropellopini</i> <i>Nais simplex</i> <i>Nemoura</i> sp. <i>Paraleptophlebia</i> sp. <i>Perlestaplacida</i> <i>Simulium venustum</i> <i>Stenonema</i> sp. Fragments*	larvae larvae adult	1 (0.05) 7 (0.37) 2 (0.10) 5 (0.26) 7 (0.37)
				adult nymph exuvia	7 (0.37)
				adult larvae	6 (0.31) 1 (0.05)
				nymph exuvia	7 (0.37) 20 (1.05) 56 (2.94)
				nymph exuvia	35 (11.82)
				exuvia	31 (4.34)
				adult	1 (0.14)
				pupae	3 (0.42)
				pupae exuvia	2 (0.28)
				larvae	4 (0.56)
				adult	1 (0.14)
				nymph	2 (0.28)
				nymph	1 (0.14)
				Hydropsyche	2 (0.28)
				larvae	8 (1.12)
				adult	1 (0.14)
				pupae	7 (0.98)
				larvae	6 (0.84)
				adult	1 (0.14)
				nymph	2 (0.28)
				exuvia	3 (0.42)
				nymph exuvia	35 (4.90)
				larvae	68 (9.52) *damaged
					FS = Far-Surface
					MS = Mid-Surface
					NS = Near-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
16 April 1980	Day (cont'd)	MS	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Hydra americana</u> <u>Macropeltopiini</u> <u>Macropeltopiini</u> <u>Nais simplex</u> <u>Paraleptophlebia</u> sp. Fragments*	exuvia adult pupae larvae adult pupae larvae nymph exuvia	34 (2.14) 1 (0.06) 4 (0.25) 2 (0.12) 1 (0.06) 38 (2.39) 2 (0.12) 2 (0.12) 5 (0.31) 17 (1.07)
		FS	<u>Allocrangonyx</u> sp. <u>Macropeltopiini</u> <u>Paraleptophlebia</u> sp. <u>Tipula</u> sp.	exuvia larvae exuvia nymph exuvia larvae exuvia	15 (0.94) 6 (0.36) 1 (0.06) 3 (0.18) 3 (0.06) 13 (0.66)
	Night	NS	<u>Allocrangonyx</u> sp. <u>Allocrangonyx</u> sp. <u>Cheumatopsyche</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Elmidae</u> <u>Hemerodromia</u> sp. <u>Heptagenia</u> sp. <u>Hydropsyche</u> sp. <u>Isotomidae</u> <u>Lirceus brachyurus</u> <u>Macropeltopiini</u>	exuvia adult larvae pupae exuvia adult adult larvae nymph larvae adult exuvia pupae exuvia	41 (2.26) 2 (0.11) 1 (0.06) 9 (0.50) 4 (0.22) 2 (0.12) 2 (0.12) 3 (0.17) 2 (0.12) 2 (0.12)
					NB = Near-Surface MS = Mid-Surface FS = Far-Surface

NS = Near-Surface

MS = Mid-Surface

FS = Far-Surface

*damaged

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
16 April 1980	Night	NS (cont'd)	<i>Nemoura</i> sp. <i>Paraleptophlebia</i> sp. <i>Paraleptophlebia</i> sp. <i>Simulium venustum</i> <i>Simulium venustum</i> <i>Stenonema</i> sp. <i>Stenonema</i> sp.	adult nymph nymph exuvia pupae exuvia larvae nymph nymph exuvia	1 (0.06) 20 (1.10)
		NB	<i>Allocrangonyx</i> sp. <i>Baetidae</i> <i>Chironomini</i> <i>Chironomini</i> <i>Chironomini</i> <i>Corixidae</i> <i>Ephemeralla</i> sp. <i>Heptagenia</i> sp. <i>Hydropsyche</i> sp. <i>Macropelopini</i> <i>Macropelopini</i> <i>Macropelopini</i> <i>Paraleptophlebia</i> sp. <i>Paraleptophlebia</i> sp. <i>Simulium venustum</i> <i>Stenonema</i> sp.	exuvia nymph pupae pupae exuvia larvae adult nymph nymph exuvia larvae pupae adult nymph nymph exuvia larvae nymph pupae exuvia adult nymph nymph exuvia larvae nymph	50 (2.75) 1 (0.06) 3 (0.17) 4 (0.23) 138 (7.61) 55 (3.10)
		MS		exuvia adult nymph larvae	43 (3.65) 43 (3.65) 23 (1.95) 5 (0.42)
				MS = Mid-Surface	MS = Far Surface
				NS = Near-Surface	NS = Near Bottom

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
16 April 1980	Night	MS (cont'd)	Chironomini Chironomini Chironomini Ephemerella sp. <u>Hemerodromia</u> sp. <u>Heptagenia</u> sp. <u>Hydropsyche</u> sp. Isotomidae Isotomidae Macropletopiini Macropletopiini Macropletopiini Macropletopiini Paraleptophlebia sp. Paraleptophlebia sp. Paraleptophlebia sp. <u>Simulium venustum</u>	pupae pupae exuvia larvae adult nymph larvae nymph exuvia larvae exuvia adult pupae pupae exuvia larvae adult nymph nymph exuvia adult larvae	15 (0.69) 1 (0.05) 2 (0.09) 1 (0.05) 1 (0.05) 1 (0.05) 4 (0.19) 2 (0.09) 7 (0.32) 1 (0.05) 3 (0.14) 21 (0.97) 1 (0.05) 6 (0.28) 66 (3.08)
		FS	Allocrangonyx sp. <u>Cheumatopsyche</u> sp. Chironomini Chironomini Ephemerella sp. Ephemeridae Heptagenia sp. <u>Hydropsyche</u> sp. Macropletopiini Paraleptophlebia sp. <u>Paraleptophlebia</u> sp. <u>Stenonema</u> sp.	exuvia larvae pupae exuvia larvae nymph larvae larvae pupae nymph nymph exuvia nymph	5 (0.50) 1 (0.10) 4 (0.40) 1 (0.10) 1 (0.10) 1 (0.10) 2 (0.20) 6 (0.60) 25 (2.49) 5 (0.50) 2 (0.20) 16 (1.60) 44 (4.39)
			MS = Mid-Surface NB = Near-Bottom NS = Near-Surface FS = Far-Surface		

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
21 May 1980	Day	NS	<u>Allocrangonyx</u> sp. <u>Chaoborus</u> sp. <u>Ephemerella</u> sp. <u>Ephemerella</u> sp. <u>Hydropsyche</u> sp. <u>Nais</u> <u>simplex</u> <u>Paraleptophlebia</u> sp. <u>Paraleptophlebia</u> sp. <u>Tabanus</u> sp.	exuvia larvae nymph nymph exuvia larvae nymph nymph exuvia pupae	23 (0.99) 4 (0.04) 4 (0.17) 6 (0.26) 1 (0.04) 1 (0.04) 16 (0.70) <u>45</u> (<u>1.95</u>)
		NB	<u>Allocrangonyx</u> sp. <u>Ephemerella</u> sp. <u>Hydropsyche</u> sp. <u>Macropelopini</u> <u>Macropelopini</u> <u>Macropelopini</u> <u>Macropelopini</u> <u>Paraleptophlebia</u> sp. <u>Simulium</u> <u>venustum</u>	adult nymph exuvia larvae pupae pupae exuvia larvae adult nymph exuvia larvae	1 (0.11) 1 (0.11) 2 (0.22) 39 (4.20) 3 (0.32) 2 (0.22) 18 (1.94) <u>58</u> (<u>6.25</u>)
		MS	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Paraleptophlebia</u> sp. <u>Simulium</u> <u>venustum</u>	exuvia pupae nymph exuvia pupae	2 (0.12) 6 (0.35) <u>8</u> (<u>0.47</u>)
		FS	<u>Allocrangonyx</u> sp. <u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Ephemerella</u> sp.	exuvia adult pupae pupae exuvia nymph exuvia	22 (1.04) 2 (0.09) 2 (0.09) 8 (0.38) 1 (0.05)

NS = Near-Surface

NB = Near-Bottom MS = Mid-Surface

FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
21 May 1980	Day	FS (cont'd)	Macropellopini Macrolopini <u>Nemoura</u> sp. <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u>	pupae pupae exuvia nymph exuvia nymph exuvia pupae	9 (0.43) 7 (0.33) 17 (0.81) 64 (3.04) 1 (0.05) (0.32)
	Night	NS	<u>Allocrangonyx</u> sp. <u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Coptotomus</u> sp. <u>Hydropsyche</u> sp. <u>Hydropsyche</u> sp. <u>Macropellopini</u> <u>Macropellopini</u> <u>Macropellopini</u> <u>Macropellopini</u> <u>Paraleptophlebia</u> sp. <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u> <u>Staphylinidae</u> <u>Stenonema</u> sp. <u>Tipula</u> sp.	exuvia adult pupae pupae exuvia larvae adult larvae larvae larvae exuvia pupae pupae exuvia larvae adult nymph nymph exuvia larvae adult nymph adult	36 (1.61) 1 (0.05) 8 (0.36) 10 (0.45) 2 (0.09) 2 (0.09) 2 (0.09) 3 (0.13) 2 (0.09) 1 (0.05) 5 (0.22) 1 (0.05) 1 (0.05) 1 (0.05) 1 (0.05) 94 (4.20) 23 (1.17) 1 (0.05) 1 (0.05) 1 (0.05)
		NB	<u>Allocrangonyx</u> sp. <u>Berosus</u> sp. <u>Chaoborus</u> sp. <u>Cheumatopsyche</u> sp.	exuvia larvae larvae larvae	40 (1.82)
			MS = Mid-Surface NB = Near-Bottom NS = Near-Surface	FS = Far Surface	

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
21 May 1980	Night (cont'd)		<i>Coptotomus</i> sp. <i>Macropeltlopini</i> <i>Macropeltlopini</i> <i>Paraleptophlebia</i> sp. <i>Stenonema</i> sp.	larvae pupae larvae nymph exuvia nymph	8 (0.41) 2 (0.10) 2 (0.10)
		MS	<i>Allocrangonyx</i> sp. <i>Allocrangonyx</i> sp. <i>Berosus</i> sp. <i>Ephemerelia</i> sp. <i>Hydropsyche</i> sp. <i>Paraleptophlebia</i> sp. <i>Paraleptophlebia</i> sp. <i>Perlestida placida</i>	exuvia adult larvae nymph larvae nymph nymph exuvia nymph exuvia	31 (1.57) 54 (2.74) 14 (0.75)
		FS	<i>Allocrangonyx</i> sp. <i>Macropeltlopini</i> <i>Macropeltlopini</i> <i>Paraleptophlebia</i> sp. <i>Paraleptophlebia</i> sp. <i>Simulium venustum</i>	exuvia pupae exuvia adult nymph nymph exuvia pupae exuvia	22 (1.18) 14 (0.75) 50 (2.68) 6 (0.31)
18 June 1980	Day	NS	<i>Chironomini</i> <i>Chironomini</i> <i>Chironomini</i> <i>Gerris</i> sp. <i>Paraleptophlebia</i> sp.	pupae pupae exuvia adult adult nymph exuvia	1 (0.04) 4 (0.18) 2 (0.09) 1 (0.04) 4 (0.18)
					8 (0.36) 4 (0.17)
					MS = Mid-Surface NB = Near-Bottom NS = Near-Surface FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
18 June 1980	Day	NB	<u>Allocrangonyx</u> sp. <u>Macropeltopini</u> <u>Paraleptophlebia</u> sp.	exuvia pupae exuvia nymph exuvia	2 (0.18) 3 (0.27) 1 (0.09) 6 (0.54)
		MS	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Paraleptophlebia</u> sp.	exuvia pupae exuvia larvae nymph exuvia	2 (0.11) 1 (0.06) 1 (0.06) 3 (0.23) 1 (0.06)
		FS	<u>Chaoborus</u> sp. <u>Chironomini</u>	pupae exuvia pupae exuvia	3 (0.21) 2 (0.14) 5 (0.35)
	Night	NS	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Chironomini</u> <u>Corixidae</u> <u>Ephemerella</u> sp. <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Paraleptophlebia</u> sp. <u>Simulium</u> <u>venustum</u> <u>Simulium</u> <u>venustum</u>	adult pupae pupae exuvia adult adult nymph exuvia pupae pupae exuvia adult nymph exuvia pupae exuvia larvae	3 (0.17) 11 (0.63) 2 (0.12) 5 (0.29) 3 (0.17) 1 (0.06) 6 (0.35) 6 (0.35) 1 (0.06) 1 (0.06) 11 (0.65) 1 (0.06)
		NB	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Ephemerella</u> sp. <u>Leptocerus</u> sp.	adult adult nymph adult	1 (0.08) 1 (0.08) 1 (0.08) 2 (0.15) 5 (0.39)

NS = Near-Surface

NB = Near-Bottom

MS = Mid-Surface

FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
18 June 1980	Night (cont'd)	MS	<u>Allocrangonyx</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u>	exuvia pupae pupae exuvia nymph adult	3 (0.17) 2 (0.12) 1 (0.06) 4 (0.23) 4 (0.23) 5 (0.52)
			SAMPLE LOST		
23 July 1980	Day	FS	<u>Chaoborus</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Hydropsyche</u> sp. <u>Macropletopiini</u> <u>Metacnephia</u> sp.	pupae exuvia pupae pupae exuvia larae pupae exuvia pupae exuvia pupae exuvia	1 (0.06) 5 (0.28) 1 (0.11) 3 (0.17) 2 (0.11) 13 (0.73) 2 (0.12)
			<u>Chimarra obscura</u>		
			<u>Chironomini</u>	larvae	1 (0.08)
			<u>Chironomini</u>	pupae	1 (0.08)
			<u>Chironomini</u>	pupae exuvia	2 (0.15)
			<u>Chironomini</u>	larae exuvia	{ 0.08 }
			<u>Hexagenia</u> sp.	adult	1 (0.08)
			<u>Metacnephia</u> sp.	nymph exuvia	3 (0.23)
				pupae exuvia	2 (0.15)
					8 (0.61) 3 (0.24)
			<u>Allocrangonyx</u> sp.	exuvia	2 (0.12)
			<u>Chironomini</u>	pupae exuvia	7 (0.41)
			<u>Heptagenia</u> sp.	nymph exuvia	1 (0.06)
			<u>Hydropsyche</u> sp.	pupae exuvia	1 (0.06)
			<u>Macropletopiini</u>	pupae exuvia	1 (0.06)
			<u>Macropletopiini</u>	adult	1 (0.06)
		MS			
			<u>Allocrangonyx</u> sp.		
			<u>Chironomini</u>		
			<u>Heptagenia</u> sp.		
			<u>Hydropsyche</u> sp.		
			<u>Macropletopiini</u>		
			<u>Macropletopiini</u>		
			NS = Near-Surface	MS = Mid-Surface	FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Benthos

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
23 July 1980	Day	MS (cont'd)	<u>Metacnephia</u> sp. <u>Paraleptophlebia</u> sp.	pupae exuvia nymph exuvia	3 (0.18) 8 (0.47) 23 (1.36) 1 (0.06)
	FS		Chironomini Chironomini <u>Heptagenia</u> sp. <u>Macropeltopjni</u> <u>Macropeltopjni</u>	pupae exuvia larae nymph exuvia pupae exuvia larae	1 (0.08) 1 (0.08) 1 (0.08) 1 (0.08)
	Night	NS	<u>Allocrangonyx</u> sp. <u>Caenis</u> sp. <u>Chaoborus</u> sp. Chironomini Chironomini Corixidae <u>Heptagenia</u> sp. <u>Hydropsyche</u> sp. <u>Hydropsyche</u> sp. <u>Macropeltopjni</u> <u>Macropeltopjni</u> <u>Metacnephia</u> sp. <u>Nemoura</u> sp. <u>Paraleptophlebia</u> sp.	adult adult adult pupae pupae exuvia adult adult nymph exuvia pupae exuvia larae pupae larae adult larae adult nymph exuvia	1 (0.08) 1 (0.08)
	NB		<u>Allocrangonyx</u> sp. <u>Chaoborus</u> sp. <u>Chaoborus</u> sp. <u>Cheumatopsyche</u> sp.	adult pupae larae larae	1 (0.08) 1 (0.08) 1 (0.08) 1 (0.08)
			NS = Near-Surface NB = Near-Bottom MS = Mid-Surface FS = Far-Surface		MS = Near-Surface NB = Near-Bottom MS = Mid-Surface FS = Far-Surface

NS = Near-Surface

FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
23 July 1980	Night	NB (cont'd)	<u>Chimarra obscura</u> <u>Chironomini</u> Ephemeridae Macroptilopinini Metacnephia sp. <u>Metacnephia</u> sp. <u>Paraleptophlebia</u> sp.	adult pupae nymph exuvia pupae pupae exuvia larvae nymph exuvia	1 (0.08) 5 (0.39)
		MS	<u>Caenis</u> sp. <u>Hydropsyche</u> sp. <u>Hydropsyche</u> sp. Macroptilopinini Metacnephia sp. <u>Nemoura</u> sp. <u>Paraleptophlebia</u> sp.	adult pupae exuvia larvae pupae exuvia larvae adult nymph exuvia	1 (0.08) 4 (0.31) 3 (0.23) 13 (1.01) 15 (1.17) 77 (1.33)
		FS	<u>Chimarra obscura</u> <u>Chironomini</u> <u>Chironomini</u> <u>Hydropsyche</u> sp. <u>Hydropsyche</u> sp. Hydroptiliidae Metacnephia sp. <u>Paraleptophlebia</u> sp.	adult pupae pupae exuvia adult pupae exuvia larvae adult larvae nymph exuvia	1 (0.06) 3 (0.19) 5 (0.32) 2 (0.13) 7 (0.45) 9 (0.57) 77 (0.70)
20 August 1980	Day	NS	<u>Chironomini</u> <u>Heptagenia</u> sp. <u>Hydropsyche</u> sp.	pupae exuvia nymph exuvia larvae exuvia	1 (0.06) 4 (0.25) 1 (0.06)

NS = Near-Surface

NB = Near-Bottom MS = Mid-Surface FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
20 August 1980	Day	NS (cont'd)	<u>Macropellopini</u> <u>Nais simplex</u>	pupae exuvia adult	3 (0.19) 9 (0.56) 2 (0.12)
		NB	<u>Allocrangonyx</u> sp. <u>Caenis</u> sp. <u>Chironomini</u> <u>Heptagenia</u> sp. <u>Macropellopini</u>	exuvia nymph pupae exuvia pupae exuvia pupae exuvia	3 (0.18) 2 (0.12) 6 (0.36) 7 (0.42) 18 (1.08) 1 (0.06)
		MS	<u>Allocrangonyx</u> sp. <u>Chaoborus</u> sp. <u>Corixidae</u> <u>Heptagenia</u> sp. <u>Macropellopini</u> <u>Nais simplex</u> <u>Paraleptophlebia</u> sp.	adult exuvia pupae exuvia larvae exuvia nymph exuvia pupae exuvia adult nymph exuvia	1 (0.06) 1 (0.06) 2 (0.12) 10 (0.60) 8 (0.48) 2 (0.12) 1 (0.06) 23 (1.38) 2 (0.12)
		FS	<u>Chironomini</u> <u>Heptagenia</u> sp. <u>Macropellopini</u> <u>Macropellopini</u> <u>Paraleptophlebia</u> sp. <u>Stenonema</u> sp.	pupae exuvia nymph exuvia pupae exuvia adult nymph exuvia nymph exuvia	1 (0.06) 6 (0.38) 2 (0.13) 2 (0.13) 1 (0.06) 23 (0.76) 2 (0.13)
20 August 1980	Night	NS	<u>Allocrangonyx</u> sp. <u>Cheumatopsyche</u> sp. <u>Cheumatopsyche</u> sp. <u>Chironomini</u> <u>Chironomini</u> <u>Ectopria nervosa</u>	adult exuvia larvae larvae exuvia pupae exuvia adult adult	1 (0.05) 1 (0.05) 2 (0.10) 7 (0.36) 1 (0.05) 1 (0.05)

NS = Near-Surface

NB = Near-Bottom

MS = Mid-Surface

FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
20 August 1980	Night	NS (cont'd)	<u>Heptagenia</u> sp. <u>Hydropsyche</u> sp. <u>Macropeltopini</u> <u>Nais simplex</u> <u>Paraleptophlebia</u> sp. <u>Tipula</u> sp. <u>Tipula</u> sp.	nymph exuvia larvae pupae exuvia adult nymph exuvia pupae exuvia adult	2 (0.10) 1 (0.05) 1 (0.05) 4 (0.21) 20 (1.03) 2 (0.10) 4 (0.21)
		NB	Chironomini Chironomini Coptotomus sp. Corixidae Heptagenia sp. <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Paraleptophlebia</u> sp.	pupae pupae exuvia adult adult adult nymph exuvia pupae pupae exuvia adult nymph exuvia	35 (1.79) 5 (0.34) 2 (0.13) 1 (0.07) 4 (0.27)
		MS	Chironomini Chironomini <u>Heptagenia</u> sp. <u>Macropeltopini</u> <u>Macropeltopini</u> <u>Nais simplex</u> <u>Paraleptophlebia</u> sp. <u>Simulium venustum</u>	pupae pupae exuvia adult nymph exuvia pupae exuvia adult nymph exuvia pupae exuvia	33 (2.23) 24 (1.62) 14 (0.94)
					27 (1.26) 8 (0.48)

NS = Near-Surface

NB = Near-Bottom

MS = Mid-Surface

FS = Far-Surface

Appendix C-2 (cont'd)

Source Water Macroinvertebrate Drift Results

Date	Time	Station	Taxon	Stage	Densities No. (No./10 m ³)
20 August 1980	Night	FS	<i>Allocranomyx</i> sp. <i>Chironomini</i> <i>Chironomini</i> <i>Heptagenia</i> sp. <i>Paraleptophlebia</i> sp.	adult pupae adult nymph exuvia nymph exuvia	1 (0.07) 2 (0.13) 1 (0.07) 1 (0.07) 3 (0.20) 4 (0.27) 4 (0.27)

NS = Near-Surface NB = Near-Bottom MS = Mid-Surface

FS = Far-Surface

APPENDIX D
Larval Fish Sampling Results
1. In-Plant
2. Source Water

Appendix D-1

In-Plant Larval Fish Sampling Results

Date	Time	Taxon	No. Fish (No./10 m ³)	Length Range (mm)	No. Eggs (No./10 m ³)
19 March 1980	Day	-	0	-	0
	Night	-	0	-	0
26 March 1980	Day	-	0	-	0
	Night	-	0	-	0
2 April 1980	Day	-	0	-	0
	Night	-	0	-	0
9 April 1980	Day	-	0	-	0
	Night	-	0	-	0
16 April 1980	Day	-	0	-	0
	Night	-	0	-	0
24 April 1980	Day	-	0	-	0
	Night	-	0	-	0
1 May 1980	Day	-	0	-	0
	Night	-	0	-	0
7 May 1980	Day	-	0	-	0
	Night	-	0	-	0
		Cyprinidae*	3	(0.49)	10.0-15.0
		Etheostominae	1	(0.16)	6.5
		Percina sp.	1	(0.16)	6.0
		Unidentified*	3	(0.49)	5.0-10.0
			8	(1.30)	
14 May 1980	Day	Cyprinidae*	3	(0.49)	5.0-10.0
		Percidae	1	(0.16)	6.8
		Unidentified*	3	(0.49)	5.0-10.0
			7	(1.14)	
	Night	Unidentified*	4	(0.65)	5.0-10.0
			4	(0.65)	

*damaged

Appendix D-1 (cont'd)

In-Plant Larval Fish Sampling Results

Date	Time	Taxon	No. Fish	(No./10 m ³)	Length Range (mm)	No. Eggs	(No./10 m ³)
21 May 1980	Day	Cyprinidae*	1	(0.16) (0.16)	5.0-10.0	0	0
	Night	Cyprinidae*	3	(0.49) (0.33)	5.0-10.0	5	(0.82)
		Catostomidae*	2	(0.82)	5.0-10.0		
		Unidentified*	5	(0.07) (0.07)	5.0-10.0	5	(0.82)
28 May 1980	Day		1	(0.07)	5.0-10.0	8	(0.58)
	Night	Unidentified*	3	(0.24) (0.24)	5.0-10.0	1	(0.08)
		Catostomidae*	1	(0.07)	5.0-10.0	1	(0.08)
		Unidentified*	3	(0.22) (0.29)	5.0-10.0	0	0
4 June 1980	Day		4	(0.07) (0.07)	5.0-10.0	0	0
	Night	Centrarchidae*	1	(0.07)	5.0-10.0	1	(0.07)
		Unidentified*	1	(0.07) (0.14)	5.0-10.0	1	(0.07)
		Unidentified*	2	(0.15) (0.15)	10.0-15.0	0	0
11 June 1980	Day	S A M P L E					
	Night	Cyprinidae*	2	(0.15) (0.15)	5.0-10.0	1	(0.07)
	Day						
18 June 1980	Day						
	Night	Cyprinidae*	3	(0.22) (0.07)	5.0-10.0	0	0
		Etheostomidae	1	(0.15) (0.44)	6.1		
		Unidentified*	2	(0.15) (0.44)	5.0-15.0	0	0

*damaged

Appendix D-1 (cont'd)

In-Plant Larval Fish Sampling Results

Date	Time	Taxon	No. Fish	(No./10 m ³)	Length Range (mm)	No. Eggs	(No./10 m ³)
25 June 1980	Day	Acipenseridae sp.*	1	(0.07)	-	2	(0.15)
	Night	Cyprinidae*	2	(0.15)	5.0	2	(0.15)
		Petromyzontidae	1	(0.07)	16.0	0	
		Cyprinidae*	1	(0.07)	5.0-10.0		
2 July 1980	Day	Catostomidae*	2	(0.15)	5.0-10.0		
	Night	Unidentified*	2	(0.15)	5.0-10.0	0	
	Day	Centrarchidae*	6	(0.44)	5.0	0	
	Night	Cyprinidae*	1	(0.07)	5.0-10.0	0	
10 July 1980	Day	Percidae*	1	(0.06)	5.0	2	(0.15)
	Night	Catostomidae*	1	(0.07)	7.0	0	
	Day	CIRCULATING PUMP DOWN FOR REPAIRS			0		
	Night	Unidentified*	1	(0.07)	0		
17 July 1980	Day	Unidentified*	5	(0.32)	5.0-10.0	0	
	Night	-	0		-	0	
	Day	Lepomis sp.*	1	(0.06)	5.1	3	(0.19)
		Percidae*	1	(0.06)	7.0	3	(0.19)
23 July 1980	Day	Catostomidae*	2	(0.12)	5.0-10.0	0	
	Night	Percidae*	1	(0.06)	7.0	0	
	Day	Unidentified	6	(0.38)	5.0-10.0	0	
	Night	Unidentified	2	(0.13)	5.0-10.0	0	

*damaged

Appendix D-1 (cont'd)

In-Plant Larval Fish Sampling Results

Date	Time	Taxon	No. Fish	No. (No./10 m ³)	Length Range (mm)	No. Eggs	No. (No./10 m ³)
6 August 1980	Day	-	0	(0.06)	-	1	(0.07)
	Night	Cyprinidae* Percidae*	1 1 2	{0.06} {0.06} {0.12}	5.0-10.0 5.0-10.0	0	0
13 August 1980	Day	-	0	(0.06)	-	0	0
	Night	Percidae*	1	{0.06}	5.0-10.0	0	0
20 August 1980	Day	Unidentified*	2	{0.13}	5.0-10.0	0	0
	Night	Cyprinidae* Lepomis sp.* Unidentified*	2 2 3	{0.13} {0.13} {0.19}	5.0-10.0 6.5-7.0 5.0-10.0	0	0
27 August 1980	Day	-	0	(0.45)	-	0	0
	Night	-	0	-	-	0	0
3 September 1980	Day	-	0	(0.13)	-	0	0
	Night	-	0	-	-	0	0
10 September 1980	Day	-	0	(0.13)	-	0	0
	Night	-	0	-	-	0	0
17 September 1980	Day	-	0	(0.13)	-	0	0
	Night	-	0	-	-	0	0

*damaged

Appendix D-2

Source Water Larval Fish Sampling Results

Date	Time	Station	Taxon	No. Fish (No./10 m ³)	Length Range (mm)	No. Eggs (No./10 m ³)
19 March 1980	Day	NS	-	0	-	0
		NB	-	0	-	0
		MS	-	0	-	0
		FS	-	0	-	0
		Day Total		0	-	0
	Night	NS	-	0	-	0
		NB	-	0	-	0
		MS	-	0	-	0
		FS	-	0	-	0
		Night Total		0	-	0
16 April 1980	Day	NS	Catostomidae*	1	(0.14)	0
		NB	-	0	8.5	(0.02)
		MS	-	0	-	0
		FS	-	0	-	0
		Day Total		1	(0.02)	0
	Night	NS	<u>Cottus carolinae</u>	1	(0.06)	9.5
		NB	<u>Percidae*</u>	1	(0.06)	7.0
		MS	<u>Percina</u> , sp.	5	(0.28)	5.0-7.0
		FS	Unidentified*	3	(0.17)	5.0-10.0
		Night Total		10	(0.57)	0
NS = Near-Surface NB = Near-Bottom MS = Mid-Surface FS = Far-Surface *damaged						

Appendix D-2 (cont'd)

Source Water Larval Fish Sampling Results

Date	Time	Station	Taxon	No. Fish	(No./10 m ³)	Length Range (mm)	No. Eggs (No./10 m ³)
21 May 1980	Day	NS	Cyprinidae Ictiobinae <u>Micropterus</u> sp.* <u>Etheostoma</u> sp. <u>Percina</u> sp.	2 1 1 3 8	(0.09) (0.04) (0.04) (0.04) (0.34)	6.0- 7.0 8.0 6.5 7.4 5.5- 6.5	0
		NB	<u>Erimyzon</u> sp.*	1	(0.11)	6.5	0
		MS	<u>Percina</u> sp.*	1	(0.06)	6.0	(0.12)
		FS	<u>Hiodon tergisus</u> Ictiobinae <u>Etheostoma</u> (<u>caeruleum?</u>)	1 1 1	(0.05) (0.05) (0.05)	7.0 6.0 6.0	0
			Day Total	13	(0.18)	0	2 (0.03)
	Night	NS	Cyprinidae <u>Notropis</u> sp. Ictiobinae <u>Percina</u> sp.	1 2 4 2	(0.04) (0.09) (0.18) (0.09)	7.0 5.0-10.0 5.0-10.0 6.0	47 (2.10)
		NB	<u>Ichthyomyzon</u> sp. Ictiobinae	1 2	(0.05) (0.70)	8.5 8.0	47 (2.10)
		MS	<u>Acipenseridae</u> sp. <u>Notropis</u> sp. Ictiobinae <u>Moxostoma</u> (<u>erythrurum?</u>) <u>Percina</u> sp.	1 1 2 1	(0.05) (0.05) (0.11) (0.05)	8.0 4.9 7.0- 9.0 14.0 5.0- 6.0	37 (1.88) 37 (1.66) 31 (1.66) 31 (1.66)
			NS = Near-Surface NB = Near-Bottom MS = Near-Bottom	7	(0.37)	31 (1.66)	
			FS = Mid-Surface				*damaged

Appendix D-2 (cont'd)

Source Water Larval Fish Sampling Results

Date	Time	Station	Taxon	No. Fish	(No./10 m ³)	Length Range (mm)	No. Eggs (No./10 m ³)
21 May 1980 (cont'd)	Night	FS	Ictiobinae <u>Etheostoma</u> sp.	3 1 4	(0.27) (0.09) (0.36)	8.0- 9.0 6.5	24 (2.13)
			Night Total	22	(0.31)		24 (2.13)
18 June 1980	Day	NS	<u>Dorosoma petenense</u> <u>Lepomis macrochirus</u>	1 1 2	(0.04) (0.04) (0.08)	4.5 5.5	0 (1.93)
		NB	<u>Dorosoma cepedianum</u> <u>Cyprinus carpio</u> Ictiobinae	1 1 2 4	(0.09) (0.09) (0.18) (0.36)	4.5 5.5 5.0- 7.0	0 0
		MS	Ictiobinae	4 4	(0.22) (0.22)	5.0- 7.0	0 0
		FS	Ictiobinae	1 1	(0.07) (0.07)	5.5	0 0
			Day Total	11	(0.17)	0	0
	Night	NS	<u>Cyprinus carpio</u> Ictiobinae <u>Percina</u> sp. <u>Lepomis</u> (<u>humilis?</u>)	1 49 3 1 54	(0.06) (2.83) (0.17) (0.06) (3.12)	7.0 5.0-10.0 4.5- 5.5 5.5	0 0 0 0
		NB	<u>Dorosoma cepedianum</u> <u>Dorosoma petenense</u> Cyprinidae spp. Ictiobinae <u>Lepomis</u> sp.	2 2 3 3 1	(0.15) (0.15) (0.23) (0.23) (0.08)	4.5- 6.0 3.0- 6.0 5.0- 7.0 6.0- 7.0 5.0	0 0 0 0 0
			NS = Near-Surface	NB = Near Bottom	MS = Mid-Surface	FS = Far-Surface	

Appendix D-2 (cont'd)

Source Water Larval Fish Sampling Results

Date	Time	Station	Taxon	No. Fish	(No./10 m ³)	Length Range (mm)	No. Eggs (No./10 m ³)
18 June 1980 (cont'd)	Night	MS	Cyprinidae Ictiobinae Etheostoma sp. <u>Percina</u> sp.	1 28 1 1	(0.06) (1.62) (0.06) (0.06) 31 (1.80)	5.0 5.0- 7.0 5.5 4.5	0
		FS	Hybopsis sp. Ictiobinae <u>Lepomis</u> <u>macrochirus</u>	1 1 2	(0.07) (0.07) (0.14) 4 (0.28)	7.5 6.0 5.5	0
			Night Total	100	(1.60)	-	0
		NS		0	0	-	1 (0.06) (0.06)
23 July 1980	Day	NB	Cyprinidae	1	(0.08) (0.08)	4.0	1 (0.08) (0.08)
		MS	Ictiobinae	1	(0.06) (0.06)	6.5	5 (0.29) (0.29)
		FS		0	0	-	0 0
		NS	Day Total	2	(0.03)	7	(0.12)
	Night		Cyprinidae Ictiobinae <u>Percina</u> sp.	2 1 1	(0.12) (0.06) (0.06) 4 (0.24)	4.0 6.0 4.0	3 (0.17)
		NB	Ictiobinae	2 2	(0.16) (0.16)	5.0- 7.0	3 (0.17) 419 419 (32.58) (32.58)
			MS = Mid-Surface	NB = Near-Bottom	MS = Mid-Surface	FS = Far-Surface	

Appendix D-2 (cont'd)

Source Water Larval Fish Sampling Results

Date	Time	Station	Taxon	No. Fish (No./10 m ³)	Length Range (mm)	No. Eggs (No./10 m ³)
23 July 1980 (cont'd)	Night	MS	Ictiobinae	$\frac{2}{2}$ $\frac{(0.13)}{(0.13)}$	6.0	$\frac{6}{6}$ $\frac{(1.68)}{(1.68)}$
		FS	Ictiobinae	$\frac{2}{2}$ $\frac{(0.24)}{(0.24)}$	6.0	$\frac{9}{9}$ $\frac{(1.07)}{(1.07)}$
			Night Total	10 (0.18)		457 (8.45)
20 August 1980	Day	NS	-	0	-	0
		NB	-	0	-	0
		MS	-	0	-	0
		FS	-	0	-	0
102	Night	NS	<u>Lepomis</u> sp.	$\frac{1}{1}$ $\frac{(0.05)}{(0.05)}$	6.8	$\frac{5}{5}$ $\frac{(0.26)}{(0.26)}$
		NB	-	0	-	50 $\frac{(3.37)}{(3.37)}$
		MS	-	0	-	20 $\frac{(1.21)}{(1.21)}$
		FS	-	0	-	8 $\frac{(0.53)}{(0.53)}$
			Night Total	1 (0.02)		83 (1.26)
10-11 Sept. 1980	Day	NS	-	0	-	0
		NB	-	0	-	0
		MS	-	0	-	0
		FS	-	0	-	0
	Night	NS	-	0	-	0
		NB	-	0	-	0
		MS	-	0	-	0
		FS	-	0	-	0
			Night Total	0 0		0 0
		NS = Near-Surface	NB = Near-Bottom	MS = Mid-Surface	FS = Far-Surface	